



SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS



ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

High Voltage Experimenter's Handbook

[\[Table of Contents\]](#) [\[Downloads\]](#) [Solaris items for sale\]](#)>

This page serves as a repository for all the bits and pieces I am collecting towards creating a modern version of the classic 1954 work by Craggs and Meek: *High Voltage Laboratory Technique*. That work, long out of print, but available from good university libraries, provided a wealth of practical information to those interested in experimentation with high voltage, either for itself, or as a necessary component of some other experiment. However, back in 1954, they didn't have high voltage silicon rectifiers, nor were such modern construction materials as Teflon, Silicone Elastomers, and fiberglass structural components available.

By the way, I've sort of used 10 kV as the starting point for High Voltage. The National Electrical Code defines a much lower starting point (300 or 600 V?), but I chose 10 kV because that's about where you have to start worrying about corona and it gets harder to find off the shelf components.

I have started to update the general organization as I have collected more information and to take advantage of the possibilities of hypertext. The "book" is arranged as several parallel tracks. The first track is a summary of the data, providing the basic practical detail without much theoretical background; the audience is the reader who just wants to make something work, and doesn't really care why. The second parallel track, with cross links to the first one, is a more theoretical discussion of the topic, typically providing references and the information necessary to extend the information in the first track. A third track consists of practical applications data, consisting of an example design using the principles in the first two tracks, experimental data, and so forth. Please send me comments at jimlux@earthlink.net, especially as to organization or topics that you have curiosity about.

Table of Contents

Introduction

Basic Theoretical Stuff

- [Basic Electrostatics](#)
- [Estimating maximum E-field](#)
- [Rogowski Profiles](#) (and [Bruce profiles](#))
- [Breakdown of gaps and Paschen's Law](#)
- [Circuit theory \(RC, RLC, etc.\)](#)
- [Measuring Watts and Vars with a VOM](#)
- [Power Factor Correction](#)

Components and Materials

- Insulators ([Gases](#), [Liquids](#), Solids)
- [Resistors](#)
- Capacitors ([Medhurst Formulas](#))
- Inductors ([Wheeler Formulas](#))
- [Fuses](#)
- [Wire](#)
- Semiconductors
- Vacuum tubes
- [Transformers](#)
 - 100% duty cycle sinusoid (power transformers)
 - shape preserving pulse transformers
 - energy preserving impulse transformers (e.g. auto ignition coils)

Measurements

- Voltage
 - [Dividers \(Resistor, Capacitor, RC\)](#)
 - Spark gaps
- Current
- Isolation
- [Electro-optical \(Kerr, Pockels, and Faraday effect\)](#)

Construction Practices

- [Corona](#)
- [Construction materials](#) ([silicones](#))
- [Epoxy Prep](#)

DC power supplies

- [Multi-stage HV generators](#)
 - Mechanical multistage
 - [Greinacher cascades](#)
 - [Cockroft Walton voltage multipliers](#)
 - some [examples of multistage generators](#)
- Electrostatic Generators
 - Van deGraaf
 - Vollrath dust machines
 - [Pelletrons](#)
 - Wimshurst, Toepler, & Holst machines

AC power supplies

- Resonance Transformers (not tesla coils, see below)
- [Tesla Coils](#)
- [Cascaded transformers](#)

Impulse generators

- [Single Capacitor](#)
- [Marx generators](#)
- [Fitch generator](#)
- Waveform shaping
- Impulse transformers

HV Square Pulse generators

- [Tailbiter circuits](#)
- Transmission line pulse forming networks
 - Coaxial Lines
 - Strip Lines
 - Lumped approximations
 - Blumlein voltage doubler

Spark Gaps

- [Breakdown of gaps and Paschen's Law](#)
- Uniform field gaps:
- Sphere gaps: [procedure & construction](#), [breakdown voltages](#)
- Rod gaps: [procedure & construction](#), [breakdown voltages](#)
- [Spark gap correction factors](#) (atmosphere, irradiation)

Switching devices

- [Relays](#)
- [Triggered spark gaps](#)
- Vacuum and gas tubes
- Semiconductors
- [Rotary spark gaps](#) (not even closed to being finished)
- [John Pasley's wonderful paper on pulsed power](#)

Regulatory issues

- OSHA
- FCC
- NEC/NESC

Suppliers

- Surplus Equipment
 - General considerations
 - [Measuring transformer parameters](#)
 - Measuring capacitor parameters
- [Master list of suppliers including addresses, phone numbers, and electronic addresses with annotations](#)

[References](#)

[What's new](#)

Copyright 1998, Jim Lux/ 3 May 1998 / [Back to home page](#) / [Mail to Jim](#) (jimlux@earthlink.net)

Online Section





Search for

RUNNING YOUR CAR ON WATER AND ORGONE ENERGY [CLICK HERE](#)



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

SOLARIS

THE SEARCH FOR NATURES
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURES POWER
SECRETS FOR 2000 AND BEYOND

The banner features the word "SOLARIS" in a bold, metallic, sans-serif font. The background is dark with stylized white lightning bolts.

THE SEARCH FOR NATURES
ABUNDANT ENERGY SECRETS

The banner features the text "ENERGY21" in a bold, metallic, sans-serif font. The background is dark with stylized white lightning bolts.

DISCOVERING NATURES POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

High Voltage Handbook Downloads

This page has links to various downloadable files that may be useful. You can either just click on the link, or you can right click (in IE) and go through the "save as" dialog.

Zip file of the whole handbook of high volatage at this web site (3 May 1998 edition) [High Voltage Handbook](#)

Copyright 1998, Jim Lux / [download.htm](#) / 3 May 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
CLICK HERE

SOLARIS

SEEKING NATURE'S SECRETS

OUR ENCYCLOPEDIA OF FREE
ENERGY FREE DOWNLOAD
VOLUME ONE [for free click here](#)



This new version of the encyclopedia free energy two is now available and is the follow up from the popular volume 1 free download from this site with many new articles diagrams and photographs.

\$30 DOLLARS AUSTRALIAN

Solaris also has available a video of the swiss ml testakica in operation with some good close ups. Video is available in VHS Pal format only.

\$30 DOLLARS AUSTRALIAN PLUS \$5 POSTAGE

NEW We also have a disk book on how to run your car on [orgone Energy/zero point energy](#). If you can duplicate what the Australian Inventor claims **NO MORE PETROL BILLS**.

I can't guarantee you will get the same results as to what the inventor claims but after viewing the details of this fuel elimination device, I must say I was truly impressed This disk in html format is available for

This disk is no longer for sale

Please use this
**CURRENCY
CONVERSION
INTERNET**
to calculate cost

Practical do it yourself formulas

Here is a collection of formulas that SOLARIS promises will save you money. As with most things now it is generally cheaper to do it yourself. These generally available generic products have a huge markup and if you make these products yourself and maybe market them locally they don't get your hard earned cash and you get what may have been theirs.

\$20 AUSTRALIAN DOLLARS
PLEASE MAKE ALL PAYMENTS
TO GEOFF EGEL 18 STURT STREET
LOXTON 5333 SOUTH AUSTRALIA AUSTRALIA

Neither special knowledge ,nor elaborate equipment is necessary for any of the formulas and complete instructions are given for the preparation of each product. The complete set of these formulas are available on a floppy disk from SOLARIS for \$35.00 Australian . Payment condition as on right.

YOU CAN SUPPORT SOLARIS
BY PURCHASING THE
FOLLOWING PRODUCTS ON
THIS PAGE AND ENABLE US
TO CONTINUE OUR MISSION
TO INFORM ALL THE WORLD
OF FREE ENERGY AND
ENERGY EMPOWERMENT.
FOR EACH INDIVIDUAL



[Introduction](#)



[Free energy V2](#)



[The swiss ml](#)



[The Hamel
spinner](#)



[What's on our
website](#)



[Energy articles](#)



[Homepage](#)



[E-mail Solaris](#)

Payment may only be made in your local currency (cash) or a Bank Draft and made payable in Australian Dollars on Australian Bank.

Your bank should be able to help here.

O
U
R

I
N
T
E
R
N
E
T

W
E
B
L
I
N
K
S

[Sign Guestbook](#) [View Guestbook](#) [Volume 1 Constructors](#) [Homework help](#)
[Join Solaris Mailing newsgroup List](#) [free download of free energy encyclopedia version 1](#)

(c) This Solaris site created and maintained by
Geoff Egel 18 Sturt Street, Loxton 5333, South Australia Australia

Please note Solaris has no connection with any commercial venture or otherwise operating in the world currently selling any portion of this website. Purchase their product at your risk

Online Section



Search for



LOOK@ME?

UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)



SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS



ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

High Voltage Experimenter's Handbook

[\[Table of Contents\]](#) [\[Downloads\]](#) [Solaris items for sale\]](#)>

This page serves as a repository for all the bits and pieces I am collecting towards creating a modern version of the classic 1954 work by Craggs and Meek: *High Voltage Laboratory Technique*. That work, long out of print, but available from good university libraries, provided a wealth of practical information to those interested in experimentation with high voltage, either for itself, or as a necessary component of some other experiment. However, back in 1954, they didn't have high voltage silicon rectifiers, nor were such modern construction materials as Teflon, Silicone Elastomers, and fiberglass structural components available.

By the way, I've sort of used 10 kV as the starting point for High Voltage. The National Electrical Code defines a much lower starting point (300 or 600 V?), but I chose 10 kV because that's about where you have to start worrying about corona and it gets harder to find off the shelf components.

I have started to update the general organization as I have collected more information and to take advantage of the possibilities of hypertext. The "book" is arranged as several parallel tracks. The first track is a summary of the data, providing the basic practical detail without much theoretical background; the audience is the reader who just wants to make something work, and doesn't really care why. The second parallel track, with cross links to the first one, is a more theoretical discussion of the topic, typically providing references and the information necessary to extend the information in the first track. A third track consists of practical applications data, consisting of an example design using the principles in the first two tracks, experimental data, and so forth. Please send me comments at jimlux@earthlink.net, especially as to organization or topics that you have curiosity about.

Table of Contents

Introduction

Basic Theoretical Stuff

- [Basic Electrostatics](#)
- [Estimating maximum E-field](#)
- [Rogowski Profiles](#) (and [Bruce profiles](#))
- [Breakdown of gaps and Paschen's Law](#)
- [Circuit theory \(RC, RLC, etc.\)](#)
- [Measuring Watts and Vars with a VOM](#)
- [Power Factor Correction](#)

Components and Materials

- Insulators ([Gases](#), [Liquids](#), Solids)
- [Resistors](#)
- Capacitors ([Medhurst Formulas](#))
- Inductors ([Wheeler Formulas](#))
- [Fuses](#)
- [Wire](#)
- Semiconductors
- Vacuum tubes
- [Transformers](#)
 - 100% duty cycle sinusoid (power transformers)
 - shape preserving pulse transformers
 - energy preserving impulse transformers (e.g. auto ignition coils)

Measurements

- Voltage
 - [Dividers \(Resistor, Capacitor, RC\)](#)
 - Spark gaps
- Current
- Isolation
- [Electro-optical \(Kerr, Pockels, and Faraday effect\)](#)

Construction Practices

- [Corona](#)
- [Construction materials](#) ([silicones](#))
- [Epoxy Prep](#)

DC power supplies

- [Multi-stage HV generators](#)
 - Mechanical multistage
 - [Greinacher cascades](#)
 - [Cockroft Walton voltage multipliers](#)
 - some [examples of multistage generators](#)
- Electrostatic Generators
 - Van deGraaf
 - Vollrath dust machines
 - [Pelletrons](#)
 - Wimshurst, Toepler, & Holst machines

AC power supplies

- Resonance Transformers (not tesla coils, see below)
- [Tesla Coils](#)
- [Cascaded transformers](#)

Impulse generators

- [Single Capacitor](#)
- [Marx generators](#)
- [Fitch generator](#)
- Waveform shaping
- Impulse transformers

HV Square Pulse generators

- [Tailbiter circuits](#)
- Transmission line pulse forming networks
 - Coaxial Lines
 - Strip Lines
 - Lumped approximations
 - Blumlein voltage doubler

Spark Gaps

- [Breakdown of gaps and Paschen's Law](#)
- Uniform field gaps:
- Sphere gaps: [procedure & construction](#), [breakdown voltages](#)
- Rod gaps: [procedure & construction](#), [breakdown voltages](#)
- [Spark gap correction factors](#) (atmosphere, irradiation)

Switching devices

- [Relays](#)
- [Triggered spark gaps](#)
- Vacuum and gas tubes
- Semiconductors
- [Rotary spark gaps](#) (not even closed to being finished)
- [John Pasley's wonderful paper on pulsed power](#)

Regulatory issues

- OSHA
- FCC
- NEC/NESC

Suppliers

- Surplus Equipment
 - General considerations
 - [Measuring transformer parameters](#)
 - Measuring capacitor parameters
- [Master list of suppliers including addresses, phone numbers, and electronic addresses with annotations](#)

[References](#)

[What's new](#)

Copyright 1998, Jim Lux/ 3 May 1998 / [Back to home page](#) / [Mail to Jim](#) (jimlux@earthlink.net)

Online Section





Search for

RUNNING YOUR CAR ON WATER AND ORGONE ENERGY [CLICK HERE](#)



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

SOLARIS

THE SEARCH FOR NATURES
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURES POWER
SECRETS FOR 2000 AND BEYOND

The word "SOLARIS" in a stylized, metallic, blocky font.The text "THE SEARCH FOR NATURE'S ABUNDANT ENERGY SECRETS" in a metallic, blocky font, set against a background of lightning bolts.The text "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.The text "DISCOVERING NATURE'S POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font, set against a background of lightning bolts.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Basic Electrostatics

Electrostatics deals with charges, potentials, and the like where things aren't changing, i.e. they're static. Basic principles of electrostatics are used all the time in high voltage work for a lot of reasons. Popular high voltage generators like the Van de Graaf are based on electrostatic principles (even though a current is flowing). The burning question in a lot of high voltage work is whether the system will electrically breakdown as the voltage is raised. This is generally a question of quasi-static potential gradients which can be answered by simple electrostatics.

[A collection of practical calculations based on the following theory.](#)

Coulomb's Law

The force on a charged point exerted by a second charge is proportional to the product of charges, and inversely proportional to the square of the distance between the charges, and acts either directly towards each other (opposite charges) or away from each other (same sign of charge).

$$F(\text{vector}) = k * q_1 * q_2 / r_{12}^2 * \text{direction}(r_{12})$$

where

$$k = 1 / (4 * \pi * \epsilon) = 8.99E9 \text{ Newton Meter}^2 / \text{Coulomb}^2$$

where ϵ is the dielectric constant of the medium (= 8.85E-12 for vacuum)

r_{12} is the scalar distance from point 1 to point 2

$\text{direction}(r_{12})$ is a unit vector from point 1 to point 2

q1 , q2 are charges on each point

Capacitance of two parallel plates

$$C = \text{epsilon} * \text{Area} / \text{DistanceBetweenPlates}$$

this neglects fringing effects, which for plates that are smaller than, say, 10 times the spacing, are pretty significant.

Capacitance of two concentric cylinders (e.g. coaxial cable)

$$C = 2 * \pi * \text{epsilon} * \text{length} / \ln(r_{\text{Outer}}/r_{\text{Inner}})$$

this assumes $\text{length} \gg r$

Capacitance of two concentric spheres

$$C = 4 * \pi * \text{epsilon} * r_{\text{Inner}} * r_{\text{Outer}} / (r_{\text{Outer}} - r_{\text{Inner}})$$

as r_{Outer} goes to infinity, the fraction $r_{\text{Outer}} / (r_{\text{Outer}} - r_{\text{Inner}})$ goes to one, leading to the following handy equation:

Capacitance of isolated sphere

$$C = 4 * \pi * \text{epsilon} * \text{radius} = \text{approx } 111.2 \text{ pF/meter}$$

this equation is derived from the equation for two concentric (nested) spheres, and letting the radius of the outer sphere go to infinity.



ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

The word "SOLARIS" in a stylized, metallic, blocky font.The text "THE SEARCH FOR NATURE'S ABUNDANT ENERGY SECRETS" in a metallic, blocky font, set against a background of lightning bolts.The text "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.The text "DISCOVERING NATURE'S POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font, set against a background of lightning bolts.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Estimating the magnitude of the Electric Field

A lot of practical high voltage design requires knowing what the maximum E-field is, for insulation design, corona reduction, etc. The exact field can, of course, be calculated numerically by solving Laplace's equation over a suitable field with appropriate boundary conditions. As complicated and time consuming as this is, it is necessary when performance is critical, in integrated circuit design, designs for absolute minimum cost, and so forth. However, for more run of the mill experimentation and use, where a little overdesign can be tolerated, approximations to the field are just as useful.

The mean or average field is just the voltage difference divided by the distance between the conductors. For the proverbial infinite flat plates, this makes the calculation simple.

$$E_{\text{max}} = E_{\text{average}} = V / \text{Distance}$$

For two concentric cylinders (i.e. like coaxial cable) the maximum field is:

$$E_{\text{max}} = V / (R_{\text{inner}} * \text{LN}(R_{\text{outer}} / R_{\text{inner}}))$$

where:

R_{inner} is radius of the inner electrode

R_{outer} is the radius of the outer electrode

$\text{LN}()$ is the log base e of the argument

V is the voltage between the electrodes

For concentric spheres, using the same variables, the maximum field is:

$$E_{\text{max}} = V * R_{\text{outer}} / (R_{\text{inner}} * (R_{\text{outer}} - R_{\text{inner}}))$$

For two parallel cylinders of equal radius:

$$E_{\max} = V * \text{SQRT}(D^2 - 4 * R^2) / (2 * R * (D-R) * \text{INVCOSH}(D / (2 * R)))$$

approx equal to: $V / (2 * R) * \text{LN}(D/R)$ if $D \gg R$

where:

D is distance between the centers of the conductors

R is the radius of the conductors

For two spheres:

$$E_{\max} = \text{approximately } V/S * F$$

where:

S is spacing between spheres = $D - 2 * R$

F is a field enhancement factor =

$$F = (S/R + 1) * \text{sqrt}((S/R + 1)^2 + 8) / 4$$

For spheres, if $S \gg R$ then $E_{\max} = \text{approx } V / (2 * R)$

For other configurations:

$$E_{\max} = E_{\text{average}} * F$$

For sphere/plane: $F = 0.94 * \text{Spacing} / \text{Radius} + 0.8$

For cylinder/plane: $F = 0.25 * \text{Spacing} / \text{Radius} + 1.0$



ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

The word "SOLARIS" in a stylized, metallic, blocky font.The text "THE SEARCH FOR NATURES ABUNDANT ENERGY SECRETS" in a metallic, blocky font, set against a dark background with white lightning bolts.The text "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.The text "DISCOVERING NATURES POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font, set against a dark background with white lightning bolts.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Rogowski profiles

There are applications which require a uniform electrical field between two electrodes such as breakdown voltage testing and large volume laser discharge cavities. The ideal infinite flat plates are somewhat difficult to realize in a lab of reasonable dimensions. Finite sized plates produce a uniform field at the middle of the plate, but the high field at the edges creates a problem.

Rogowski (also variously spelled Rogovski, which is closer to the Russian pronunciation) developed a technique that starts by determining a realizable field, then constructing an electrode shaped so that the surface of the electrode lies on an equipotential surface. He started with an analytical solution of the field due to a finite plane plate parallel to an infinite plane. A more empirical approach was taken by Bruce, described [elsewhere](#).

Taken to an extreme, the field at a large ($d \gg x$) distance from any charge distribution approximates the field from a point charge, i.e. a sphere. The arbitrary charge could be replaced by a sphere of appropriate size and voltage/charge, and the E field would be the same.

For example, consider the field between two finite flat plates. In the center region, the field is quite uniform. However, if one actually constructed such electrodes, you would find that the high field strength at the edges of the plates would almost certainly cause problems from dielectric breakdown. The solution is to construct electrodes that follow an equipotential surface which is some distance from the flat plate electrode. Since it is farther away, the field strength is lower, and breakdown is not as much of an issue.

For an arbitrary shaped electrode, determining the electric field, particularly in the dynamic case, is quite difficult, and would normally need to be done by numerical techniques. However, for some special cases, that happen to be useful, an analytical expression for the field can be developed. Such a case would be the finite flat plates above.

$$x = A(\phi + e^{\psi} \cos \psi')$$

$$y = A(\psi' + e^{\psi} \sin \psi')$$

If $\psi \leq 0.4\pi$, the field is greatest in the center region between the plates, and less everywhere else. If you make the electrode follow this contour, the breakdown voltage between the electrodes will be the same as if they were an infinite uniform field.

For the special case of $\psi = \pi/2$, the equations above reduce to:

$$x = \frac{a \phi}{\pi}$$

$$y = \frac{a}{\pi} \left(\frac{\pi}{2} + e^{\psi} \right)$$

Copyright 1998, Jim Lux / rogowski.htm / 24 Jan 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



A horizontal banner with a dark background featuring stylized lightning bolts. The word "SOLARIS" is written in a large, metallic, blocky font on the left side.

SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

A horizontal banner with a dark background featuring stylized lightning bolts. The text "ENERGY21" is written in a large, metallic, blocky font on the left side, with the "21" in red.

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Bruce profiles

Bruce developed a series of electrode shapes that approximated an ideal uniform field. In practice, breakdown measurements are made with spherical electrodes, because small changes in the surface of a uniform field electrode can cause field irregularities which in turn dramatically affects the breakdown voltages. Also, a deviation from parallelism of the opposing electrode faces can cause significant deviations from a large uniform field area. Spheres are easier to make and keep smooth, even though there isn't a "nice" analytical solution to the field between the electrodes. Furthermore, if there is a misalignment between the spheres, the region between the spheres is still geometrically the same.

The Bruce profile is a figure of revolution, starting with a flat plane in the center, with a sine curve used as a transition to a circular section at the edge. The idea is to have a large area of uniform field (2 flat plates) with a gradually increasing radius of curvature to the edge. The Bruce profile apparently wasn't originally developed with the intention of finding an analytically nice E field, but was an empirically derived method to reduce the edge effects.

Copyright 1998, Jim Lux / bruce.htm / 8 March 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)

A horizontal banner with a dark background featuring stylized lightning bolts. The word "SOLARIS" is written in a large, metallic, blocky font on the left side.

SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

RUNNING YOUR CAR ON WATER AND ORGONE ENERGY

CLICK
HERE



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
CLICK HERE

The banner features the word "SOLARIS" in a large, metallic, blocky font on the left. To its right, the text "THE SEARCH FOR NATURES ABUNDANT ENERGY SECRETS" is written in a smaller, similar font. The background is dark with stylized white lightning bolts.The banner features the text "ENERGY21" in a large, metallic, blocky font on the left. To its right, the text "DISCOVERING NATURES POWER SECRETS FOR 2000 AND BEYOND" is written in a smaller, similar font. The background is dark with stylized white lightning bolts.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Paschen's Law

In 1889, F. Paschen published a paper (*Wied. Ann.*, **37**, 69) which set out what has become known as Paschen's Law. The law essentially states that the breakdown characteristics of a gap are a function (generally not linear) of the product of the gas pressure and the gap length, usually written as $V = f(pd)$, where p is the pressure and d is the gap distance. In actuality, the pressure should be replaced by the gas density.

For air, and gaps on the order of a millimeter, the breakdown is roughly a linear function of the gap length: $V = 30pd + 1.35 \text{ kV}$, where d is in centimeters, and p is in atmospheres.

Much research has been done since then to provide a theoretical basis for the law and to develop a greater understanding of the mechanisms of breakdown. Some of this will be described in the rest of this section, but it should be realized that there are many, many factors which have an effect on the breakdown of a gap, such as radiation, dust, surface irregularities. Excessive theoretical analysis might help understanding why a gap breaks down, but won't necessarily provide a more accurate value for the breakdown voltage in any given situation.

[more info](#)

Copyright 1997, Jim Lux/ 14 Sep 1997 / paschen.htm / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)

The banner features the word "SOLARIS" in a large, metallic, blocky font on the left. To its right, the text "THE SEARCH FOR NATURES ABUNDANT ENERGY SECRETS" is written in a smaller, similar font. The background is dark with stylized white lightning bolts.

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

The word "SOLARIS" in a stylized, metallic font.The text "THE SEARCH FOR NATURE'S ABUNDANT ENERGY SECRETS" in a metallic font.The text "ENERGY21" in a stylized, metallic font.The text "DISCOVERING NATURE'S POWER SECRETS FOR 2000 AND BEYOND" in a metallic font.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Basic Circuit Theory

Circuit theory for high voltage systems is essentially the same as for any other circuit. Ohm's law and Kirchoff's Voltage and Current laws still apply. The actual circuits for most high voltage equipment are actually quite simple, so not much analytical work is necessary to get an understanding of the expected behavior. In fact, slavish use of mathematical circuit modelling may not be the best approach for high voltage circuits, because the characteristics of the components are not known accurately, and the effects of dielectric breakdown (e.g. corona) are unpredictable. In much of high voltage engineering, empiricism still rules the day.

RC circuits

discharge: $V(t) = V_{\text{initial}} * \text{EXP} (-t / (R*C))$

The product $R*C$ is referred to as the time constant.

LC circuits

RLC circuits

Nonlinear elements

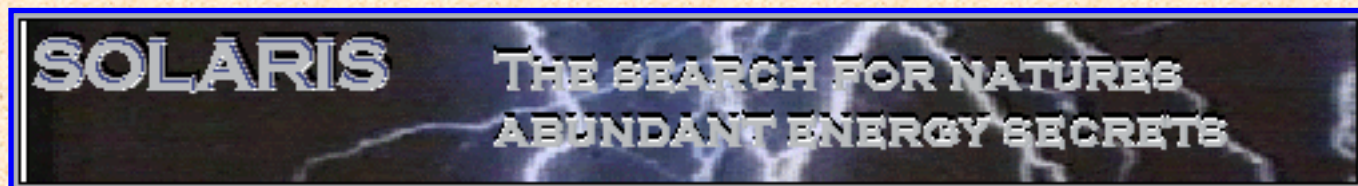
The most common non-linear circuit encountered in high voltage circuits is a spark or arc. The voltage drop across a high pressure arc (e.g. in a xenon flash tube) is proportional to the square root of the current. This is known as the Goncz relation.

$$E = K_0 * \text{SQRT}(I)$$

Another common non-linear element is the essentially constant voltage glow discharge, typified by a neon lamp. In fact, glow discharges can have a negative resistance characteristic, in that the voltage drop across the discharge decreases as the current increases.

In some simple cases (like a xenon flash tube discharging in a simple RLC loop), a fairly accurate analytical solution can be determined. In more complex cases, numerical integration is the best approach.

Copyright 1997, Jim Lux / circuit.htm / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



The word "SOLARIS" in a stylized, metallic, blocky font. The background is dark with white lightning bolts.The text "THE SEARCH FOR NATURES ABUNDANT ENERGY SECRETS" in a metallic, blocky font. The background is dark with white lightning bolts.The text "ENERGY21" in a stylized, metallic, blocky font. The background is dark with white lightning bolts.The text "DISCOVERING NATURES POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font. The background is dark with white lightning bolts.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Measuring active and reactive power with just a VOM

If you just measure the RMS voltage and RMS current and multiply them, you get the apparent power. As long as the load is purely resistive, the apparent power is equal to the active power. For a reactive load, though, where the voltage and current are out of phase, the apparent power will be greater than the active power. Measuring active power is a bit tricky and is traditionally done by a watt meter (or more commonly a watt hour meter, like that measuring the electrical energy consumption of your house). Watt meters (and watt hour meters) instantaneously multiply the voltage and current and integrate the result, so they measure true active power.

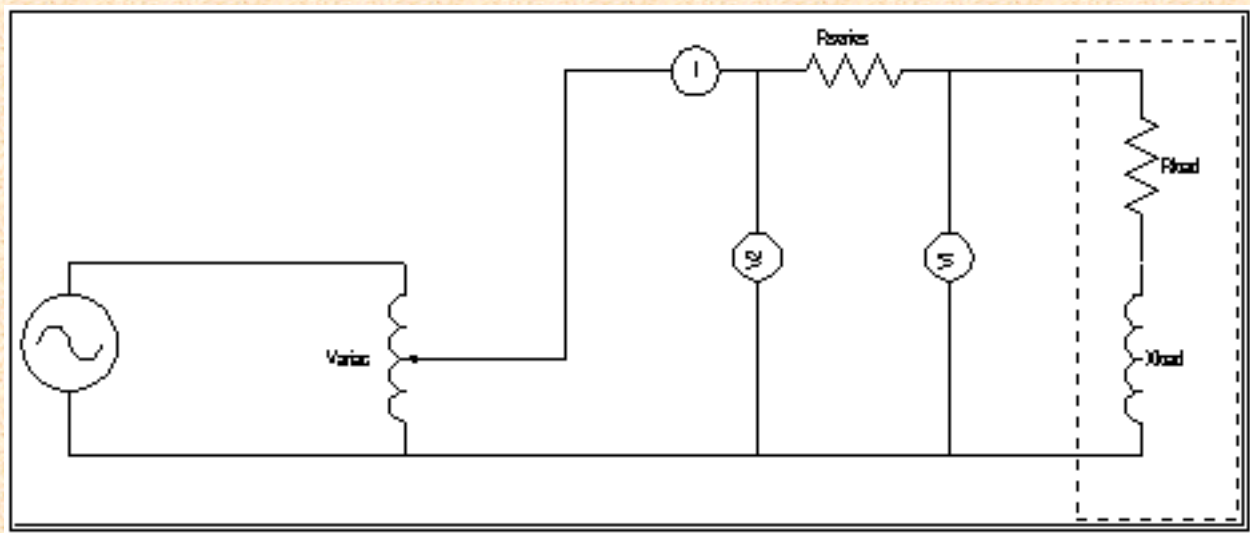
Commercial power monitors actually have an a/d that samples the voltage and current waveform and do the math internally, which makes measurements for three phase power systems much easier. If you have enough a/d channels on your data acquisition system, and are handy with software, you can do the same. These units will correctly calculate power for non-sinusoidal waveforms, as well.

You can use a dual trace oscilloscope to measure the phase shift between the current and voltage and use that to calculate active power using the equation

$$\text{active power} = \cos(\theta) * \text{apparent power}$$

where θ is the phase difference between voltage and current. The term $\cos(\theta)$ is the power factor, typically in the range .80-.95 for motors, fluorescent light ballasts, and the like.

However, say all you have is a trusty multimeter, and you need to measure active power or power factor. With a suitable resistor and a variac, you can measure active power, reactive power, etc. Set up the following circuit:



The load is represented by a resistance (R_{load}) and a reactance (X_{load}) in series. The series resistor shouldn't be too big, say 2-10 ohms. Make sure it can dissipate the power. If your load is going to draw 10 amps, and you have a 10 ohm resistor, it is going to dissipate 1000 Watts. In use, you set the output of the variac to get the load voltage to be whatever its rated input voltage is, e.g. 115Volts. To do the calculation, you'll need the following measurements:

- The RMS voltage at the load (call that V_1)
- The RMS voltage out of the variac (call that V_2)
- The RMS current through the load (call that I)
- The resistance of the series resistor (call that R_{series})

Now do the calculation:

Resistive component of load

- $$R_{load} = ((V_2/I)^2 - (V_1/I)^2 - R_{series}^2)/(2 * R_{series})$$

Reactive Component of Load

- $$X_{load} = \sqrt{(V_2/I)^2 - R_{load}^2}$$

(Of course, you don't know the sign of the reactive component from this measurement.)

Active power = $R_{load} * I^2$

Reactive Power = $X_{load} * I^2$

If you want to determine if the reactive load is capacitive or inductive, you can add a small capacitor or inductor (the reactive impedance must be less than the existing circuit's) to the circuit, make the measurements again, and see if X_{load} got bigger or smaller. For instance, if you had measured a

reactive impedance of 5 Ohms, and then you added a capacitor and got a reactive impedance of 6 Ohms, then the original reactive impedance was capacitive. If the reactive impedance decreased, then the original reactive impedance was inductive.

LIMITATION

The above technique does not necessarily work for non-sinusoidal waveforms. A good example of a non-sinusoidal waveform is the current drawn by a capacitor input filter (e.g. the input of a switching power supply) or the output of a phase controlled light dimmer.

About [power factor correction](#).

Copyright 1998, Jim Lux/ revised 30 Apr 1998/ [HV Handbook](#) / [Jim's Home Page](#) / [Email to Jim](#)



The word "SOLARIS" in a stylized, metallic, blocky font.The text "THE SEARCH FOR NATURES ABUNDANT ENERGY SECRETS" in a metallic, blocky font, set against a dark background with a lightning bolt.The text "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.The text "DISCOVERING NATURES POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font, set against a dark background with a lightning bolt.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Power Factor Correction

Many loads are highly inductive, such as lightly loaded motors and illumination transformers and ballasts. You may want to correct the power factor by adding parallel capacitors. You can also add series capacitors to "remove" the effect of leakage inductance that limits the output current.

Why correct the power factor?

The current flow through the circuit is increased by the reactive component. Normally, loads are represented by a series combination of a resistance and a purely imaginary reactance. For this explanation, it is easier to contemplate it as an equivalent parallel combination. The diagram below illustrates a partially reactive load being fed from a real system with some finite resistance in the conductors, etc.

The current through the reactive component itself dissipates no power, and neither does it register on the watt hour meter. However, the reactive current does dissipate power when flowing through other resistive components in the system, like the wires, the switches, and the lossy part of a transformer. Switches have to interrupt the total current, not just the active component. Wires have to be big enough to carry the entire current, etc. Correcting the power factor reduces the amount of oversizing necessary.

Correcting power factor

Given the reactive load component (X_{load}), you can calculate the capacitance to exactly match it using the equation:

$$X_c = 2 * \pi * 60 / C = 377 / C$$

or, rearranging: $C = 377 / X_c$

Power factor correction capacitors are often rated in kVar, instead of uF, because that is how the

power company works. Say a factory has several thousand horsepower worth of motors at .85 power factor. They might have a reactive component of several hundred kVar. At a distribution voltage of 14,400 volts, this would require a capacitor with an impedance of about 1037 ohms, or about 2.5 microfarads, a reasonable sized and priced package. However, if you were crazy enough to try to compensate this at 230 volts, you would need about .01 Farads (i.e. 10,000 uF), a sizeable package.

For very large systems, even capacitors get unwieldy. One approach is to use large over excited synchronous motors which look like capacitors, electrically. Another approach is clever systems of thyristors and inductors which simulate the capacitive reactance by drawing "displacement current".

Loads that draw non-sinusoidal current

Classic reactive loads, like transformers, lighting ballasts, and AC motors still have a sinusoidal current flow. The phase of the current is just shifted from that of the supply voltage. However, there are some loads which draw distinctly non-sinusoidal currents. The most recently notorious is the switching power supply in a PC. These power supplies start with a bridge rectifier feeding a capacitor, and so, particularly at part load, draw their current in little peaks, when the instantaneous line voltage is above the capacitor voltage, forward biasing the rectifier. Another notorious non-sinusoidal current draw is the popular phase controlled light dimmer, which uses a TRIAC or SCR to reduce the RMS voltage to the load by turning on partway through the half cycle. Not only is the current waveform highly non-sinusoidal, but it is also out of phase with the voltage supply. Hence, these loads have a non-unity power factor, and draw reactive power.

However, to compensate these loads, you have to come up with a means to supply the reactive current at the appropriate times. A simple capacitor doesn't do this. A capacitor only compensates nice sinusoidal power factor lags, like those from linear (non-saturating) inductors.

Example of Power Factor Correction

Let's take an example. A 3/4 HP electric motor has a power factor of .85. The nameplate current is 10 Amps at 115 Volts, or 1150 Volt Amps.

- Apparent power = 1150 Volt Amps
- Active power = $.85 * 1150 = 977.5$ Watts
- Reactive Power = $\text{sqrt}(1150^2 - 977.5^2) = 605$ VAR

So, we need 605 var of power factor correction. Calculating the required impedance from $Q = E^2/X$

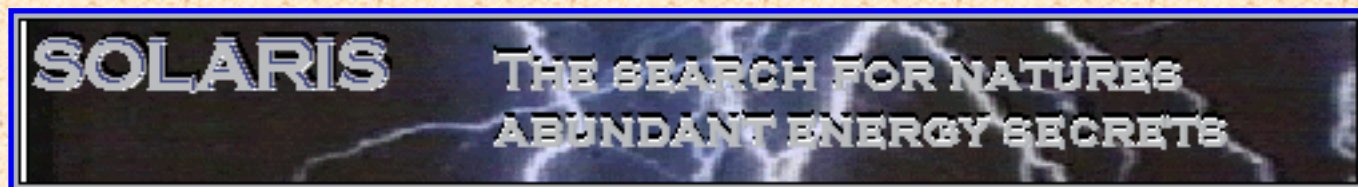
- $605 = 115^2/X \Rightarrow X = 115^2/605 = 21$ ohms
- $C = 1 / (2 * \pi * f * X) = 1 / (377 * 21) = 126$ uF

which is a fairly large capacitor. Furthermore, it will have a current of about 5.2 amps flowing through it, so its series resistance should be pretty low, or it will dissipate a fair amount of energy.

If the line voltage were higher, the correction impedance would be increased as the square of the line

voltage. The capacitance would be reduced as the square of the line voltage. That is, if the same motor were run off 230 Volts, the capacitor would only need to be 31.5 uF. And if we were to do power factor compensation at the distribution voltage of 4160 volts (for example), you would only need about .1 uF. This is why power factor correction is usually done in the distribution network at MV or HV, and not at the end voltage.

Copyright 1997, Jim Lux /revised 4 Dec 1997/ pfc.htm / [HV Handbook](#) / [Home Page](#) / [Email to Jim](#)



The word "SOLARIS" in a stylized, metallic font.

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

The text "ENERGY21" in a stylized, metallic font.

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Insulating gases

Electronegative gases make good insulators since the ions rapidly combine with the ions produced in the spark. However, they tend to be corrosive. Some gases though, dissociate only where the discharge is (or wants to be), making them particularly good insulators.

Gases with electronegative species (i.e. halogens such as chlorine) make good insulators, hence the popularity of SF₆, which is not only dense (breakdown voltage is roughly proportional to density) but is mostly Fluorine, a highly electronegative element. The halogenated hydrocarbon refrigerants are also a popular insulator. CCl₄, CCl₂F₂, CCl₃F, and C₂Cl₂F₄

References:

M.T. Rodine and R.G. Herb, *Phys. Rev.*, **51**, 508, 1937

E.E. Charlton and F.S. Cooper, *Gen.Elect.Rev.*, **40**, 438, 1937

Unfortunately, the cost of insulating gases has greatly increased in the last few years largely due to the various treaties regulating halocarbon refrigerants. The traditional Freons (R-12, R-22) are not being produced any more, and are quite expensive. Since the regulatory thrust eliminated chlorinated alkanes, modern refrigerants are relying more on fluorinated or per-fluoro hydrocarbons (e.g. HC-134a). Unfortunately, plant capacity is limited, and plants that used to make SF₆ are now making fluorinated hydrocarbons resulting in much higher prices for SF₆. In the mid 1980's SF₆ was about \$3-4/lb. Now, in the mid 90's, it is about \$100/lb. Since a pound is only about 10 liters, filling up a large insulating tank with SF₆ has become a very expensive proposition.

The breakdown voltage of most gases can be increased by increasing the absolute pressure. In the case of some gases, there is a limit imposed by the liquefaction point at normal operating temperatures (i.e. Freon 12 liquifies at 5 atmospheres). Mixtures of gases can overcome some of these issues and a mixture of Freon 12 and Nitrogen was popular.

One disadvantage of the halogenated compounds is that the dissociation products are highly corrosive, so it is important that operating voltages remain well below corona starting voltages. Even air forms highly reactive nitrogen oxides and other corrosive compounds, particularly if there is any water vapor present. High pressure air can also support combustion due to the oxygen content. Pure Nitrogen seems to not have these disadvantages, although its breakdown is only about 15 % better than air.

Air - approximate breakdown is 30 kV/cm at 1 atm. = $30 + 1.53d$ where d in cm. The breakdown of air is very well researched, to the point where the breakdown voltage of a calibrated gap is used to measure high voltages.

Freons- The vapor pressure of CCl_2F_2 (R-12) is 90 psi at 23C, where the breakdown is some 17 times that of air at 1 atm. An even higher insulating strength can be obtained by adding nitrogen to the saturated CCl_2F_2 to bring the total pressure to the desired value. The saturated vapor pressure of $\text{C}_2\text{Cl}_2\text{F}_4$ at 23C is 2 atm abs, at which condition it has a relative dielectric strength of 5.6 times N_2 at 1 atm

Sulfur Hexafluoride (SF_6) - Sulfur Hexafluoride is probably the most popular insulating gas, although its cost has risen dramatically recently.

Hydrogen - Hydrogen gas is not a particularly good insulator (65% of air) from a breakdown voltage standpoint. Its very low viscosity and high thermal capacity make it an insulating gas of choice for high speed, high voltage machinery such as turbogenerators. There isn't an explosion hazard, provided that the oxygen content in the hydrogen tank is kept below the flammable limit (around 5%). Of course, hydrogen has lots of other handling problems, including hydrogen embrittlement, it leaks through very tiny holes (even the pores in the metal tanks), and perfectly colorless, but very hot, flames.

Relative spark breakdown strength of gases

Gas	N_2	Air	NH_3	CO_2	H_2S	O_2	Cl_2	H_2	SO_2	$\text{C}_2\text{Cl}_2\text{F}_4$	CCl_2F_2
V/V_{air}	1.15	1	1	0.95	0.9	0.85	0.85	0.65	0.30	3.2	2.9

From: Cobine, p 166, from J.J. Thomson & G.P. Thomson, "Conduction of Electricity through Gases", Vol 2, p.506

SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

SOLARISTHE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS**ENERGY21**DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Insulating Liquids

Property	Transformer Oil	Cable Oil	Capacitor Oil	Askarels	Silicone Oils
Breakdown strength (20 C, 2.5mm sphere gap)	150	300	200	200-250	300-400
Relative Permittivity (50Hz)	2.2-2.3	2.3-2.6	2.1	4.8	2-73
Loss Tangent (50Hz)	.001	.002	0.25E-3	0.60E-3	.001
Loss Tangent (1 kHz)	.0005	.0001	0.10E-3	0.50E-3	0.1E-3
Resistivity (Ohm -cm)	1e12-1e13	1e12-1e13	1e13-1e14	2e12	3e14
Specific Gravity at 20 C	0.89	0.93	0.88-0.89	1.4	1.0-1.1
Viscosity at 20 C (cStokes)	30	30	30	100-150	10-1000
Refractive Index	1.4820	1.4700	1.4740	1.6000	1.5000-1.6000
Saponification	0.01	0.01	0.01	<0.01	<0.01
Thermal Expansion	7e-4/deg	7e-4	7e-4	7e-4	5e-4
Max permissible Water content (ppm)	50	50	50	<30 negligible	<30 negligible

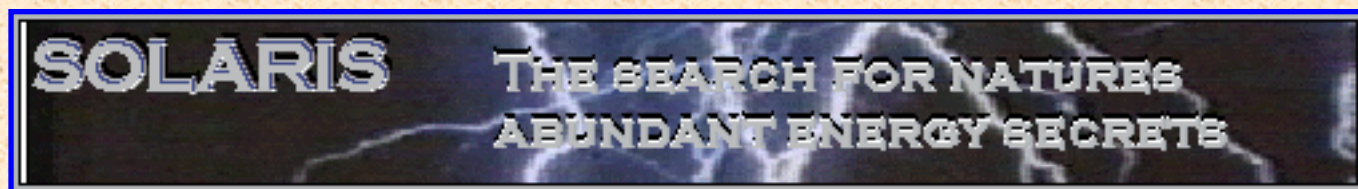
Pure Liquids

Pure liquids often have much higher breakdown strengths than commercial liquids. For instance, the addition of 0.01% water to insulating oil reduces its breakdown strength to 20% of the "dry" value. Compare, for example, the breakdown for Transformer Oil is usually taken as 150 kV/cm (see above

table), but when highly purified, it is almost 8 times that, or 1000 kV/cm.

Liquid	Max Breakdown Strength MV/cm
Hexane	1.1-1.3
Benzene	1.1
Transformer Oil	1.0
Silicone	1.0-1.2
Liquid Oxygen	2.4
Liquid Nitrogen	1.6-1.9
Liquid Hydrogen	1.0
Liquid Helium	0.7
Liquid Argon	1.10-1.42

Copyright 1998, Jim Lux / filename here / revised date / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



The word "SOLARIS" in a stylized, metallic, blocky font.The text "THE SEARCH FOR NATURE'S ABUNDANT ENERGY SECRETS" in a metallic, blocky font, set against a dark background with white lightning bolts.The text "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.The text "DISCOVERING NATURE'S POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font, set against a dark background with white lightning bolts.

[Content on this page supplied with permission from this web site of Jim Lux](#)

High Voltage Resistors

Even such a mundane component as a resistor has special requirements when it comes to high voltage applications. The usual little 1/4 watt carbon film resistor used in most other electronics is only rated to 250 or 500 volts, a far cry from the kilovolt levels needed. The voltage limitation is usually set by power dissipation issues: a 10K resistor with 1 kV across it dissipates 100 watts! And, of course, the physical length of the device of around a centimeter means that around 5-10 kV, arcing around the resistor body is a significant problem. There are a number of manufacturers of resistors intended specifically for high voltage applications, and of course, you can construct a resistor suitable for your application.

Commercial products

- High resistance, low power - These are typically used for measuring high voltages as part of a voltage divider (or as a meter series multiplier). Generally constructed by thin film techniques on a ceramic substrate of appropriate size for the voltage rating. Suppliers include Caddock, Gigohm,
- High precision - Used in precision voltage dividers for measurement applications.
- High power - Typified by the products of the Cesewid corporation (formerly Carborundum), these units are designed to take large peak or average powers and are often constructed so they are non-inductive. A typical application would be as a current limiting device in a capacitor discharge circuit, components in pulse forming/shaping networks, or as a energy dump load. Suppliers include Cesewid and Maxwell Labs..

Home built

- Using conventional products well beyond their catalog ratings - The power dissipation and breakdown voltage issues may be addressed by potting or immersing the resistor in some suitable substance: silicone, oil, high pressure gas, etc. You'll need to do some engineering and/or testing on the system to make sure it will work as planned, e.g. potting in silicone may increase the breakdown voltage, but will reduce the max power dissipation. There are some good [reasons not to use wirewound power resistors](#), even though their nominal breakdown

voltage is fairly high.

- Strings of small low voltage resistors work very nicely, although their construction is labor intensive. This is a popular way to make high precision voltage dividers, because you can inexpensively obtain high precision resistors, and the whole assembly can be potted to reduce corona problems. Important design issues which need calculation include power dissipation, breakdown voltage, and overall precision.
- Water resistors - Actually water and some ionic salt, these are usually self constructed and are generally of low resistance. Accurate resistance control and stability is hard to achieve, but there are many applications which don't require accuracy, including charging resistors for capacitor banks and energy dump loads. I've gathered some design criteria, equations and a discussion on construction details into a [summary](#).

Copyright 1997, Jim Lux/ resistor.htm / [Back to High Voltage Main Page](#) / [Back to home page](#) / [Mail to Jim](#) (jimlux@earthlink.net)



**SOLARIS**THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS**ENERGY21**DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Self Capacitance of an air core coil Medhurst formula

Capacitance (pF) = K * Diam (cm)

where K is an empirical function of Length/Diameter

L/D	K
5.0	0.81
4.5	0.77
4.0	0.72
3.5	0.67
3.0	0.61
2.5	0.56
2.0	0.50
1.5	0.47
1.0	0.46

Summarized from Medhurst in *Wireless Engineer* V24.281 (Feb 1947) page 35, and V24.282 (May 1947), p. 80 by Rzeszotarski

SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

**SOLARIS****THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS****ENERGY21****DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND**

[Content on this page supplied with permission from this web site of Jim Lux](#)

Wheeler Formulas for Inductance

These formulas, developed by Wheeler at the (then) NBS, give approximate inductances for various coil configurations. They are primarily based on empirical measurements, and are accurate to a few percent.

Single layer air core solenoid

$$L \text{ (uH)} = r^2 * n^2 / (9 * r + 10 * l)$$

where

r = coil radius in inches

l = coil length in inches

n = number of turns

Multi layer air core solenoid

$$L \text{ {uH}} = 31.6 * N^2 * r1^2 / (6*r1 + 9*L + 10*(r2-r1))$$

L{uH} = Inductance in microHenries

N² = Total Number of turns on coil Squared

r1 = Radius of the inside of the coil {meters}

r2 = Radius of the outside of the coil {meters}

L = Length of the coil {meters}

Note the similarity to the formula for the single layer air core coil. Hope this helps everyone.

$$L \text{ (uH)} = 0.8 * a^2 * n^2 / (6*a + 9*b + 10*c)$$

where

a = average radius of windings

b = length of the coil

c = difference between the outer and inner radii of the coil.
all dimensions in inches.

It states that it is accurate to 1% when the terms in the denominator are about equal. This is also an equation by Wheeler. It applies as long as the coil has a rectangular cross section.

Flat "pancake" coil

$$L \text{ (uH)} = r^2 * n^2 / (8 * r + 11 * w)$$

where

r = radius to center of windings in inches

w = width of windings (in inches)

n = number of turns

Copyright 1998, Jim Lux / wheeler.htm / 4 April 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)





[Content on this page supplied with permission from this web site of Jim Lux](#)

High Voltage Fuses

A fuse is a circuit element designed to melt when the current exceeds some limit, thereby opening the circuit. In high voltage and high power applications, some additional design considerations come into play. For instance, if the length of the fuse wire or strip is short enough, an arc will form between the ends maintaining the circuit as long as there is current to supply it. In systems with high peak current capability (i.e. with capacitors and low impedance circuitry), the fuse can be melted and vaporized so fast that an explosion occurs. This phenomenon is actually used in Exploding Bridge Wire detonators to create a shockwave that detonates high explosive.

The basic design equation for fuses is the Preece equation (W.H. Preece, *Royal Soc. Proc.*, London, **36**, p464, 1884) for wires in free air:

$$i = A * D^{1.5}$$

where A is a constant depending on the metal and D is the diameter of the wire.

Fuse Wire	A (d in inches)	A (d in mm)	Melting temp (deg C)	Boiling temp (deg C)
Copper	10244	80.0	1083	2300
Aluminum	7585	59.3	660	1800
German Silver	5230	40.9		
Platinum	5172	40.4	1774	4300
Silver*	3200	49.8	960	1950
Iron	3148	24.6	1535	3000

Tin	1642	12.8	232	2260
Lead	1379	11.8	327	1620
Tungsten*	105	1.5	3370	5900

*Exponent in the equation should be adjusted to 1.287 for silver and 1.32 for tungsten.

Table taken from Standard Handbook for Electrical Engineers, 6th ed., Sec 15, p153.

Some fuses put the wire inside an insulating tube so that the tube walls can contain the gases created by the vaporized wire. The tube walls also cool the gases extinguishing the arc. In exploding wire type fuses, the tube walls reflect a shock wave back to the center of the arc channel increasing the pressure to raise the breakdown voltage. Expulsion protector tube type fuses use the expanding gases to actually blow the arc out the end of the tube. One author comments: "Care should be taken in locating the vents of the expulsion gaps, for flaming gas is blown for a considerable distance upon operation.... [Flames may range] from 5 ft for a 1,000 amp crest current to 12 ft for a 10 kA crest current." (Cobine, p411)

Fuses may be filled with a refractory material: silica (sand), alumina, or zirconia. The arc energy is used up in fusing the filler. Silica can absorb about 2 kJ/g.

In many circuits, the creation of an arc is actually necessary, since it provides a gradually increasing voltage drop as it cools to "gradually" interrupt the circuit. The energy dissipated in the arc also absorbs the inductive energy stored in the circuit. A sudden total interruption may cause very high terminal voltages due to series L. A similar problem crops up in the design of circuit breakers or other interrupters.

Here is another design equation due to I.M. Onderdonk:

$$I_{fuse} = Area * \sqrt{\log((T_{melt}-T_{ambient})/(234-T_{ambient})+1) / (Time * 33)}$$

where

- T_{melt} = melting temp of wire in deg C
- T_{ambient} = ambient temp in deg C
- Time = melting time in seconds
- I_{fuse} = fusing current in amps
- Area = wire area in circular mils

Practical example> 16 gauge copper wire: Tmelt = 1083, Area = 2581 circ mil, Time = 5 sec, diam = .0524 inches

Using Preece equation:

$$= 10244 * .0524^{1.5} = 123 \text{ Amps}$$

Using Onderdonk equation:

$$I_{\text{fuse}} = 2581 * \text{SQRT}(\text{LOG}((1083-25)/(234-25)+1)/(5*33))$$

$$= 2581 * \text{sqrt}(\log(1058/209+1)/165)$$

$$= 2581 * \text{sqrt}(.0047)$$

$$= 178 \text{ Amps}$$

Copyright 1997, Jim Lux / 4 October 1997 / fuses.htm / [high voltage main page](#) / [Back to home page](#) / [Mail to Jim](#)





[Content on this page supplied with permission from this web site of Jim Lux](#)

High Voltage Wire and Cable

There are two issues which need attention with high voltage wiring. The first is the level of insulation necessary to prevent arcs to adjacent components or wiring. The second is the diameter (or effective diameter) necessary to reduce corona losses. Reduction of corona is important because a common failure mode for insulation is the formation of small defects (i.e. pinholes) in the insulation due to corona discharges within the insulation.

With bare conductors, air is the insulator, and clearance distances can be calculated using standard values for the breakdown of air. A common rule of thumb which is very conservative is 1 inch per 10 kV. Since the breakdown field for air is around 71 kV/inch, this provides a 7:1 safety factor.

Popular insulation materials for hookup type wire are polyethylene, PTFE, rubber, and silicone, particularly the latter. Neon signs are a cost sensitive application, so inexpensive wire (\$.15/ft) rated at 15 kV with polyethylene insulation is widely available. Rubber is popular for test leads at the 5 kV level, although many rubbers degrade in the presence of ozone, which is often present in HV equipment. High quality high voltage wire has silicone insulation which is quite flexible and high temperature resistant. Typical prices for silicone insulated wire range from \$.20/ft for 10kV rated to \$2.00/ft for 50 kV rated.

Corona resistant wire is typically constructed with a central copper core surrounded by a semiconducting sheath, which in turn is surrounded by the insulation. The semiconducting sheath effectively increases the diameter of the wire, reducing the tendency for corona discharge. Suppliers of such wire include Belden, Caton, Tally, etc.

Coaxial cable of the RG-8 (RG-213) family is often used as high voltage cabling for several tens of kV. Grounding the outer shield makes the field distribution inside the cable very even, reducing the field concentrations that start corona. RG-8 is rated at 5 kV RMS, however, the polyethylene insulation is (.285-.01??) .120 inches thick which corresponds to 120 kV breakdown. I suspect that the 5kV rating (7 kV pk) allows for a substantial VSWR in transmission line use without breakdown. Certainly, many systems use RG-8 at 25 kV, and I have seen some at 50 kV using RG-8 as a conductor. Also, the field strength at the inner conductor is higher than that at the outer conductor

Equation here.

Having the outer surface of the cable at ground potential also confers some safety advantages. Don't forget though, that in systems with sufficient stored energy, the coax can literally explode in the event of a dielectric failure. If you have several tens of kJoules stored up, the energy has to go somewhere. At least you won't get shocked, just burned.

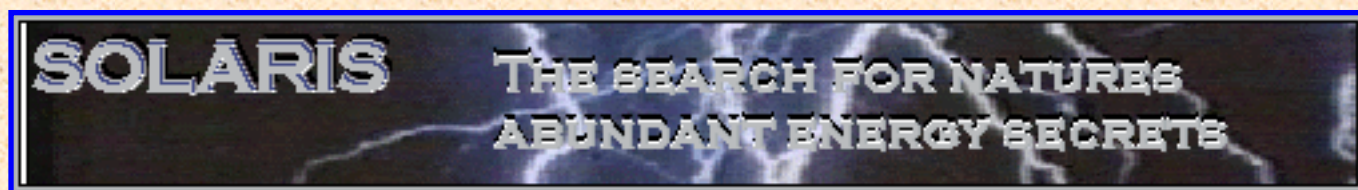
Coaxial cable using foamed dielectrics (e.g. RG-8X) are not useful, since the nitrogen used to make the foam has a much lower breakdown than the PE. The same goes for RG-59 cable TV remnants, because they are usually foamed insulation (cheaper and lower loss).

Coaxial cable also has the advantage of low series impedance in pulsed circuits, as does other types of transmission lines such as twinlead and quadline.

The so-called UHF connector (SO-279, PL-259) can be modified as a high voltage connector for use with RG-8 family coax by drilling out the center and extending the center conductor (of the plug) into a tube with a banana jack at the end. The jack can be modified by mounting the threaded outer housing (drilled out) on a block of insulator (acrylic, G10 glass epoxy).

Another ubiquitous source of high voltage hookup wire is spark plug cable for automotive use. The more common variety has a resistive core (used to slow the rise time reducing EMI) of a few kOhms per foot. A less common variety, called solid core or copper core, the conductor is normal wire. Spark plug cable typically has a very rugged silicone or hypalon jacket, as well as a fibrous armor layer. Spark plug cable costs about \$1/ft

Copyright 1997, Jim Lux/ hvwire.htm / [Back to High Voltage Main Page](#) / [Back to home page](#) / [Mail to Jim](#) (jimlux@earthlink.net)



The word "SOLARIS" in a stylized, metallic, blocky font.The text "THE SEARCH FOR NATURE'S ABUNDANT ENERGY SECRETS" in a metallic, blocky font, set against a background of lightning bolts.The text "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.The text "DISCOVERING NATURE'S POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font, set against a background of lightning bolts.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Voltage Dividers

Resistors, Capacitors, RC combinations

A general method for measuring high voltages is to use a voltage divider composed of two impedances in series. The ratio of impedance is such that the voltage across one of the elements is some convenient fraction (like 1/1000) of the voltage across the combination.

To make the power consumption of the divider as low as possible, the impedances are quite large: 10's of Gigaohm ($1e9$ ohms) might be used for measuring megavolt level signals (resulting in a current of a few tens of microamps). In an ideal world, the impedances would be pure resistors. The physically large size and the high impedances of high voltage equipment means that parasitic inductances and capacitances can be significant. Even at 60 Hz, a 10pF parasitic C has an impedance of 260 Megohm. 10 pF is roughly the capacitance of a 10 cm radius sphere (8" diameter). If the resistor string is 2 meters long, it's inductance is probably several microhenries, not particularly significant at power line frequencies, but a significant concern at the higher frequencies encountered in fast impulse work. Measuring voltages or potentials with any AC component is greatly affected by these parasitic reactances, and much of high quality divider design goes to minimizing or compensating their effect.

For making AC measurements, purely capacitive dividers are popular. A fairly small capacitor forms the upper arm of the divider, and a larger, lower voltage capacitor forms the bottom. High pressure gas capacitors are popular for the high voltage arm. A high pressure gas capacitor can provide a reasonable capacitance with a high voltage rating in a physically small package, which is important for measurements on fast transients.

Thermal effects

Small as the current is through most high value resistive dividers, it may constitute a significant amount of power, which goes into heating up the resistive elements. This heating will cause a change in the value of the resistor, changing the overall ratio of the divider.

Classic standards work, as reported in Craggs & Meek, used manganin resistors. Manganin has an extremely low temperature coefficient of resistance (1.5 ppm/deg C) (see Resistance Wire Table) compared to Nichrome (13 ppm) or Copper (ppm).

Immersing the entire resistive divider in oil or rapidly circulating dielectric gas (e.g. SF6 or dry air) also ensures that all components are at the same temperature, so that, while the absolute values might change, the ratios will remain constant, for DC at least. Resistance value changes will change the parasitic RC time constants, changing the frequency response.

Voltage Coefficient of Resistance

Some resistive materials show a change in the resistivity as a function of the impressed electric field strength. This would manifest itself as a change in the resistance as the voltage changes. A long string of individual resistors, each run at a relatively low voltage, should not show this effect.

Safety Considerations

In the classic series resistor method for measuring voltage, the high value resistor string is in series with a sensitive current measuring meter (typically a d'Arsonval meter). If the resistor were to fail shorted, or flash over, the high voltage would appear across the meter, possibly producing a personnel safety hazard, as well as destroying the meter. A simple safety precaution is a spark gap across the meter, set for a kilovolt or so, that will arc over in case of a series resistor failure.

Another means is to measure current through the high value resistor by measuring the voltage across a resistor with a high impedance meter.

Good, reliable ground connections for the low end of the divider are essential. Consider the circuit shown below:

If the ground connection at A is broken, the full high voltage will appear on the measuring device, limited by the inevitable internal arcing or failure. Fortunately, the power will most likely be limited by the high series resistance of the divider.

Physical construction of voltage dividers



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)



SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS



ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Electro-optical measurements (Kerr, Pockels, and Faraday)

Conventional means of measuring high voltages and currents rely on the measurement consuming a (hopefully) small amount of the power from the system. For instance, a resistive divider does draw some small amount of current. In power engineering, this small power is called the "burden".

Instead of directly measuring the quantity of interest, you can measure the changes in properties of some material as a result of the surrounding electrical or magnetic field. The power required for making the measurement is provided by the measuring equipment itself. One family of these techniques relies on the changes in optical properties of certain materials in electrical and magnetic fields: the Kerr effect, the Pockels effect, and the Faraday effect.

All of these techniques rely on various mechanisms by which a material rotates the polarization of light passing through. The amount of rotation depends on the electric or magnetic field. The performance is determined largely by how well you can measure the change in polarization of the light. High quality polarizing film has a transmission ratio of 1000:1 between aligned and crossed.

If one wanted to measure the E field around an operating Tesla coil, as well as the waveforms, the electro-optic sensor could be mounted on a long insulated rod with fiber optic cables to send the light to and from the measuring cell. An alternate scheme could be to use a laser and appropriate prisms or mirrors to send the light out to the cell along the support and to return it to a detector. In the latter case, the sensor itself could be mounted to the high voltage terminal, with the laser and detector mounted at some distance away.

Kerr Cells

Often used to create extremely high speed shutters, the Kerr effect is an anisotropic change in the index of refraction of a substance in response to an electric field. A practical implementation has the Kerr substance (often nitrobenzene, which has a very high Kerr Constant) between two crossed polarizers. The polarization of the light is rotated in proportion to the square of the E field, allowing

some light to pass through the polarizers. As a shutter, the response time of the Kerr Cell is limited mainly by how fast the E field can be changed.

The problems with a Kerr Cell are: nitrobenzene is a volatile solvent which is remarkably toxic; the effect is proportional to the square of the E-field, which is no problem for a shutter application, but not as appropriate for a measurement application.

[\(more theoretical discussion of Kerr Effect\)](#)

Pockels Cells

The Pockels effect is similar to that of the Kerr effect, except that the change in index is linearly proportional to the electric field. Substances such as KDP (Potassium Dihydrogen Phosphate), KD*P (Deuterated KDP) and LiNbO₃ (Lithium Niobate) show large Pockels effects and are very popular as electro-optic modulators for laser work.

One problem with Pockels sensors is the cost of the crystals, particularly in large sizes. A small 1 cm diameter crystal suitable for turning on and off a laser beam isn't particularly expensive (several hundreds of dollars), but a larger one for use as a photographic shutter would be prohibitively expensive. For a HV measuring application, the cell could be on the scale of millimeters, particularly if fiberoptic cables are used.

[\(more theory\)](#)

Faraday Rotation

Faraday rotation is a magnetic effect. Notable in high density lead glass, the rotation is proportional to the magnetic field. A chunk of lead glass 1" thick and 2" in diameter would need a field of .5 Tesla (5000 Gauss) to rotate the polarization 90 degrees. (This is about 10,000 ampere turns for that physical size). The rotation is proportional to the length of the optical path and to the magnetic field, so a longer piece of glass makes a more sensitive detector.

Faraday rotation does provide a handy way to measure the current in EHV or UHV power lines. A piece of lead glass (which can be quite long) is placed near the power cable and a polarized laser is used to measure the rotation. In a Tesla coil application, lead glass sensors connected by fiber optic cables could be used to measure the current at various parts of the coil. For that matter, a glass fiber of the appropriate material could be used as the sensor itself.

[\(more theory\)](#)

There have been some *Scientific American* "Amateur Scientist" columns dealing with Kerr Cells and Faraday modulators.

SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

SOLARISTHE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS**ENERGY21**DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Corona

Corona is caused by the electric field next to an object exceeding the breakdown value for air (or whatever it is immersed in). Since the magnitude of the field is inversely proportional to the radius of curvature, sharper edges break down sooner. The corona starting voltage is typically 30 kV/cm radius. Dust or water particles on the surface of the object reduce the corona starting voltage, probably by providing local areas of tighter curvature, and hence higher field stress.

The easiest case to analyze is that of a sphere. The magnitude of the electric field at the surface of a sphere in free space is simply the voltage/radius. Note that if the sphere is near another conductor, the field is no longer uniform, as the charge will redistribute itself towards an adjacent conductor, increasing the field.

Since corona is fundamentally a breakdown phenomenon, it follows Paschen's law: the voltage is a function of pd . Double all the dimensions and halve the gas pressure, and the corona voltage will be pretty much the same.

Corona Surface Factor

The following table gives empirically determined correction factors for various surface conditions. These factors are multiplied by the corona starting voltage (or field) to determine the corrected voltage.

<u>Condition of Conductor</u>	<u>m0</u>
New, unwashed	0.67-0.74
Washed with grease solvent	0.91-0.93
Scratch-brushed	0.88
Buffed	1.00
Dragged and dusty	0.72-0.75
Weathered (5 months)	0.95

Weathered at low humidity	0.92
For general design	0.87-0.90
7 strand concentric lay cable	0.83-0.87
19, 37, and 61 strand concentric lay cable	0.80-0.85

Source: [Cobine](#), p278 quoting W.S. Peterson, *AIEE Trans*, **52**, 62, 1933

Eliminating or reducing corona

Smoothly radiusing the corners of objects at high voltages relative to nearby objects will reduce the local field strength.

Put the sharp corner in something with a higher breakdown strength than air. The trick here is to make sure that you have really got the replacement substance in contact with the conductor. By making the high field occur within a substance with a higher breakdown than the surrounding air, corona can be reduced.

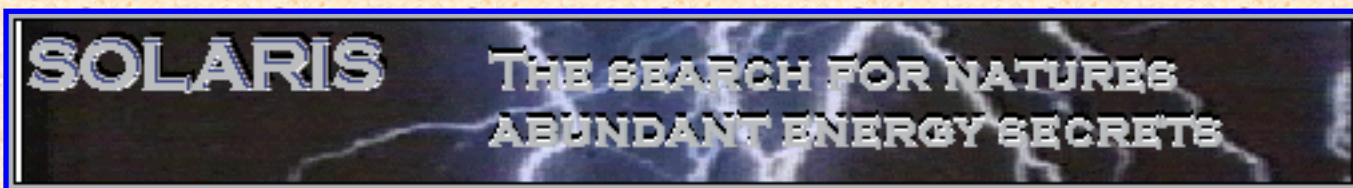
Covering sharp corners with an insulating film increases the corona starting voltage at the points with high E-field stress. Generically known as "corona dope", this is an enamel or polystyrene paints or gels that you can apply. Glyptal is one example, and clear nail polish has also been used. Clear acrylic spray paint is another alternative, although the coating is quite thin.

Potting the entire assembly in an insulator (traditionally paraffin or sulfur were used, silicone RTV is a more popular modern alternative) achieves the same result. Immersing the assembly in oil or other insulating fluids will also work. All of the potting and immersion techniques depend on removing the air or gas bubbles to work. Commercial manufacturers pull a vacuum on the container while the assembly is being potted to facilitate the removal of the air bubbles. Experimenters building polyethylene and aluminum foil capacitors for tesla coils run them at low powers using the electrostatic forces between the plates to vibrate and pump the air bubbles out.

A popular approach to reducing corona on wires is to surrounding the conductor by a semiconducting film or layer of greater radius. This effectively increases the radius of the object, and hence lowers the field strength. You may not need a huge amount of copper to carry the required current (often micro or milliamps), but you want the diameter of the conductor large enough to reduce the corona. Wire of this type is manufactured by Belden, Rowe-Talley, and Caton, among others.

Field grading rings are often used on high voltage equipment to control the electric field distribution. Rather than rely the field that would exist in free space between two charged conductors, a series of other conductors are interposed at intermediate voltages. The intermediate voltages are derived from a capacitive or resistive divider. A capacitive divider may be a simple as the interelectrode capacitances of the grading rings themselves.

Running the system in a tank at high pressure, or in an insulating gas, will increase the corona starting voltage.





[Content on this page supplied with permission from this web site of Jim Lux](#)

High Voltage Construction Materials

High voltage systems are characterized by high stresses, often of an impulse nature. The stresses are both electrical (in the case of insulators that have to withstand the high voltage) and mechanical (either from the often heavy components or from electromagnetic forces). The common requirement that the structural member be electrically insulating eliminates normally popular construction materials like steel and aluminum from consideration.

Insulating structural materials seem to fall in two classes: ceramics and plastics. Ceramics are typified by the fired porcelain insulators seen on high voltage transmission lines and as insulating bushings on equipment. The wide array of modern plastics (e.g. Plexiglas) and composites (e.g. fiberglass) have revolutionized practical HV circuit construction (although the actual circuit design remains pretty much the same). Modern adhesives (like cyanoacrylates and epoxy) also are very useful.

[Silicones](#)

What does electrical grade mean?

What this usually means is that it complies with UL 94V-0, which is a flammability spec. Many plastics burn quite well as well as emitting toxic fumes when they burn. The UL spec means that the plastic is "self extinguishing", that is, once the source of ignition is removed, the plastic won't continue to burn.

Electrical grade can also refer to the absence of contaminants in the plastic, so that it has well defined dielectric properties. Plastics are popular because they can be recycled. However, the recycling process means that there may be contaminants in the plastic which dramatically change either the resistivity, the loss factor, or the dielectric constant. A quick and dirty test of dielectric properties is to put a chunk of the plastic in a microwave oven and see if it gets hot or it arcs.

As always, don't rely on the words: check the specs.

The short list of plastic and properties

Acrylics - Plexiglas, Perspex - A generally useful material that is easily machined, although it has an annoying tendency to chip or shatter.

Polycarbonate - Lexan - Somewhat more expensive than acrylic, but it is much stronger although a bit softer. It doesn't shatter like acrylics do, which is why it is used for bulletproof windows.

Nylon - in virgin grades, a good insulator. It doesn't cold flow like Teflon.

PTFE - Teflon - a great insulator and it has a really low coefficient of friction. It does cold flow, so it shouldn't be used where it is under static load.

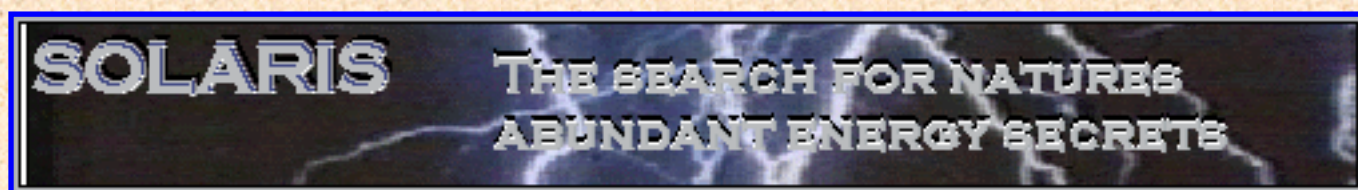
Acetal Copolymer - Delrin - Easily machinable, stronger than nylon. Black delrin is black because of they use carbon black as a filler. Obviously, this alters its electrical properties significantly.

PVC - a good insulator when virgin grade. It is soft, and gets even softer at a fairly low temperature, so don't use it for structural purposes. PVC pipe makes handy non-structural standoff insulators, and so forth.

Polyethylene - Good dielectric properties, terrible mechanical ones. Sheets of low or high density polyethylene are used in making capacitors, insulating panels, and so forth. The higher density grades (e.g. UHMW - ultra high molecular weight) are useful as bearing surfaces at a substantially lower cost than teflon.

Structural Fiberglass/Polyester composite- Extren - Structural fiberglass is an incredibly useful material. It is available in pretty much the same shapes as aluminum and steel (e.g. Angle, I-beam, square and round tubes, etc.). It can be used much like aluminum, in terms of density, strength, and cost. It is about twice as flexible as aluminum, and is noticeably weaker across the member (i.e. in shear), however, for construction of structures that have to take significant loads (i.e. cap banks, marx generators, etc.) its insulating properties are a godsend.

Copyright 1997, Jim Lux / material.htm / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)





UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

The word "SOLARIS" in a bold, metallic, sans-serif font.

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

The text "ENERGY21" in a bold, metallic, sans-serif font, with the "2" in red.

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Silicones

Silicones are used for adhering, potting and sealing. They come in two basic forms, 1 part, which cure on exposure to air, moisture, or UV light, and 2 part, which cure when mixed.

In general, silicones have good electrical and high temperature properties, and are also quite solvent resistant, which raises quite a problem if you have to remove something that has been siliconed.

Suppliers:

[General Electric](#)

[Silpak](#)

Copyright 1998, Jim Lux / silicone.htm / 14 March 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
CLICK HERE

The word "SOLARIS" in a stylized, metallic, blocky font.The text "THE SEARCH FOR NATURES ABUNDANT ENERGY SECRETS" in a metallic, blocky font, set against a dark background with white lightning bolts.The text "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.The text "DISCOVERING NATURES POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font, set against a dark background with white lightning bolts.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Surface Preparation for Epoxy Bonding

Proper surface preparation before bonding with epoxies is essential. Here is a summary of prep techniques taken in a larger part from "the Bell Jar".

Aluminum and Aluminum Alloys

1. Degrease with trichloroethylene
2. Dip in the following solution for 10 minutes:
 - 3 parts sodium dichromate
 - 20 parts water
 - 10 parts 95% sulfuric acid
3. Rinse in ambient tap water
4. Rinse in hot (65-75 degrees C) distilled water
5. Air dry
6. Note: Some alloys, such as #360, only require one to three minute dip in the acid dichromate.

Copper, Brass, and other Copper Alloys

1. Degrease with trichloroethylene
2. Dip in either of the two following solutions
 - 6 parts ferric chloride
 - 200 parts water
 - 30 parts concentrated nitric acid (70%)OR
 - 25% ammonium persulfate for 1-2 minutes
3. Rinse with distilled water and dry

Ferrous alloys other than Stainless

1. Degrease with trichloroethylene
2. Sandblast with 100 grit sand or etch in 15% hydrochloric acid (equal parts concentrated hydrochloric acid and water) for 10 minutes. Etched surfaces should be rinsed immediately and dried with hot air.

Freshly sandblasted or etched steel begins to rust immediately; therefore adhesive should be applied as soon as the surface has been prepared.

Stainless Steel, Chromium

1. Degrease with trichloroethylene
2. Etch with concentrated hydrochloric acid for 15 minutes at room temperature OR with a solution of
90 parts water
40 parts 96% sulfuric acid
0.2 parts Nacconol NR (National Aniline)
for 10 minutes at 65 degrees C followed by
90 parts water
15 parts 70% nitric acid
2 parts 48% hydrofluoric acid
3. Rinse in hot distilled water and dry with hot air.

Zinc, Lead, Nickel, and Tin

1. Degrease
2. Abrade(sandblast)
3. Degrease

Stone, Ceramics, Glass

1. Degrease
2. Wire Brush (for stone) and sandblast
3. Rinse with water and dry

Polar Thermoplastics (Nylon, ABS, Polycarbonate, Acrylate)

1. Degrease with trichloroethylene
2. Abrade
3. Degrease

Polyethylene, Polypropylene

1. Degrease with trichloroethylene
2. Oxidize by immersing in a solution:

- 7 parts sodium dichromate
- 10 parts water
- 150 parts concentrated sulfuric acid
- for 10-15 minutes
- 3. Rinse with hot distilled water
- 4. Dry and coat with adhesive immediately

Thermoset plastics (Epoxies, Polyurethane, Polyester, Melamine, Phenolic)

- 1. Degrease with acetone, MEK, or trichloroethylene
- 2. Mechanically abrade (sandblast)
- 3. Degrease

Copyright 1998, Jim Lux / epoxyprep.htm / 5 Mar 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



**SOLARIS****THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS****ENERGY21****DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND**

[Content on this page supplied with permission from this web site of Jim Lux](#)

Multi-Stage High Voltage Generators

Multistage HV generators create high voltage by connecting a number of lower voltage sources in series to produce the required voltage. At some voltage level, it becomes impractical to generate the required voltage in one circuit, usually due to component construction and insulation problems, so a multistage approach is the only way to get the voltages required. There are also some applications, linear particle accelerators and photomultiplier dynode bias supplies being two notable ones, where you actually want a series of stepped voltages. The fact that the power supply creates them without needing some sort of external voltage divider (which will potentially dissipate some power) is an advantage. The best known form of a multistage HV generator is the Cockroft-Walton voltage multiplier, which will be discussed in a later section.

In general, multistage generators are built as a stack of basically identical stages. Power is fed in at the bottom (low voltage) end of the stack and transmitted up the stack by some means either mechanical or electrical to power a series of independent power supplies. Economies of scale can be realized because all the stages are identical (or nearly so). Further economies result from the generally lower cost of lower voltage components, even in multiple quantities.

Start with a crude, but effective, system that uses mechanical means to transmit the power up the stack. A single large motor turns an insulating shaft which runs up the stack. At each stage, a generator is connected to the shaft and takes mechanical power from the shaft. The generator powers an appropriate supply which is connected in series with the supplies in the stages above and below. This system would potentially be heavy and the mechanical problems of transmitting significant power up an insulating shaft would need to be addressed. Also, electrical stability might be a problem, although with a sufficiently sophisticated central control and fiber optics it could probably be made to work quite well.

The technique of transmitting power by mechanical means has been used to generate isolated electrical power at high common mode voltages. For instance, the ion supply in the collector of a Van deGraaf accelerator is often powered from a generator driven by the charging belt. This technique has also been used to provide filament power to rectifier tubes in a more conventional Cockroft Walton or Greinacher stack.

The next system to be considered transmits the power between the stages by means of transformers with a high isolation voltage. This system, described by Greinacher in 189x (?), requires that the transformers be large enough to carry the power for all the stages above. So, either you give up having identical stages, or the transformers have a lot of excess capacity in the upper stages. It is a simple generalization to do the same thing using a third winding on the power supply transformer of the stage, essentially sharing the iron core. This system has the advantage that the output voltage of the entire stack can be easily adjusted by changing the input voltage to the first stage. company name here manufactures high voltage power supplies based on this principle.

Later design improvements use air core transformers operating at RF which has the multiple advantages of eliminating the weight of the iron and making the required filter capacitors much smaller, although rectifiers and other parasitic losses become larger at higher frequencies.

The Dynamitron takes this approach to the ultimate, using the accelerator tube itself as one plate of the filter capacitor.

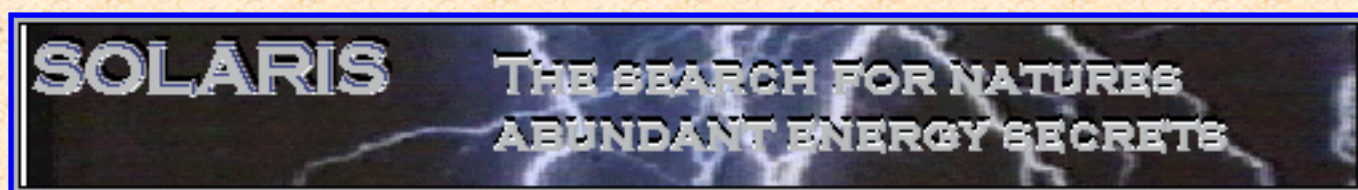
The Cockroft Walton configuration uses a chain of capacitors to transmit the power up the stack.

Analysis of the Cockroft-Walton configuration

optimum number of stages

ripple

Copyright 1997, Jim Lux / staged.htm / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)





UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)



SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS



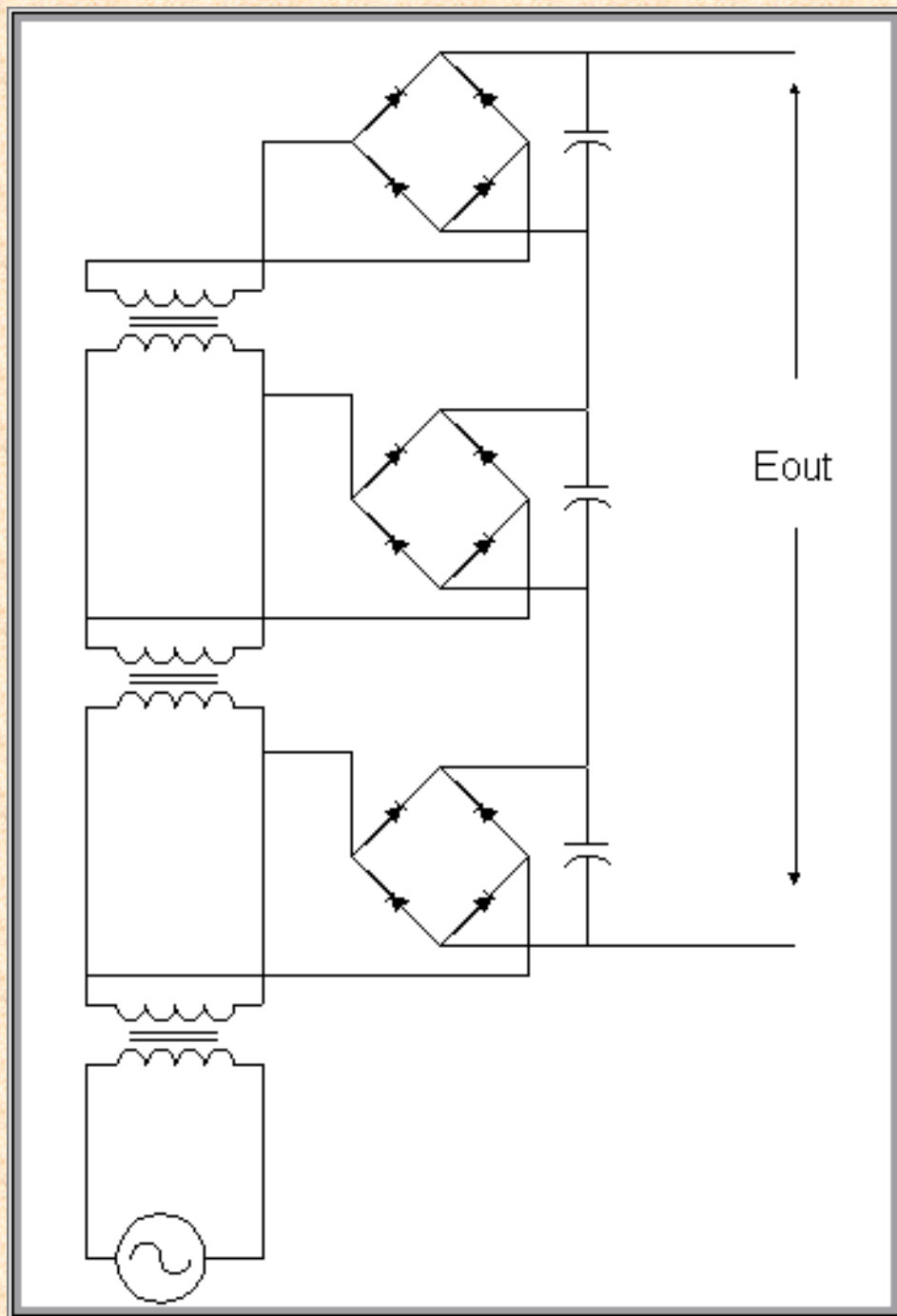
ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Greinacher Cascades

One strategy for generating high voltages, without requiring excessive insulation on the transformers, is a cascade arrangement as described by Greinacher in 1920 (?). A cascade of transformers, each insulated at twice the stage voltage, is connected as shown in the following figure. The stage voltages are rectified and filtered with the filter capacitors connected in series to develop the desired output voltage.



The above figure shows the transformers with iron cores, however, with the use of a higher frequency source (i.e. RF), air core transformers can be used with the attendant reduction in weight. In fact, any means of getting the power up the cascade can be used, providing the losses are acceptable and the insulation level is appropriate. A cascade of capacitors could also be used, in which case, the system starts to look like a classic Cockcroft-Walton multiplier.

This scheme can also be used to generate high AC voltages, by omitting the rectifiers and filter capacitors, and connecting the stages together, essentially creating a cascade of autotransformers.

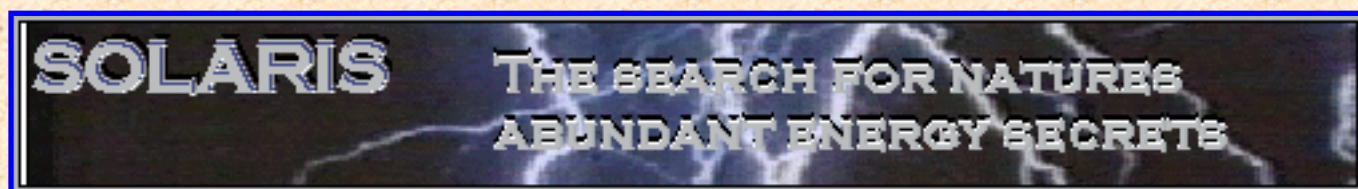
The significant design issue is that the "bottom" transformer must be sized to carry not only the power for the bottom stage, but also the $N-1$ stages above. One could design a system using ever decreasing transformer sizes, however, the economies of scale and convenience in building multiple identical sections means that the upper stages have over capacity.

A similar strategy, using a third, or tertiary winding on the transformers has also been used. This has the advantage that the power can be transmitted between stages using relatively low voltages, requiring fewer turns of thicker, easier to handle wire. The tertiary winding must be insulated from the other windings by the full stage voltage however. This strategy is of some use when inexpensive surplus transformers with an appropriate winding are available, an example of which is [here](#).

Another form of the system is to use isolation transformers between the stages, insulated for the stage voltage, and a separate HV transformer at each stage, feeding the rectifiers and filters as appropriate.

Some examples of such cascades are [here](#).

Copyright 1997, Jim Lux / grein.htm / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)





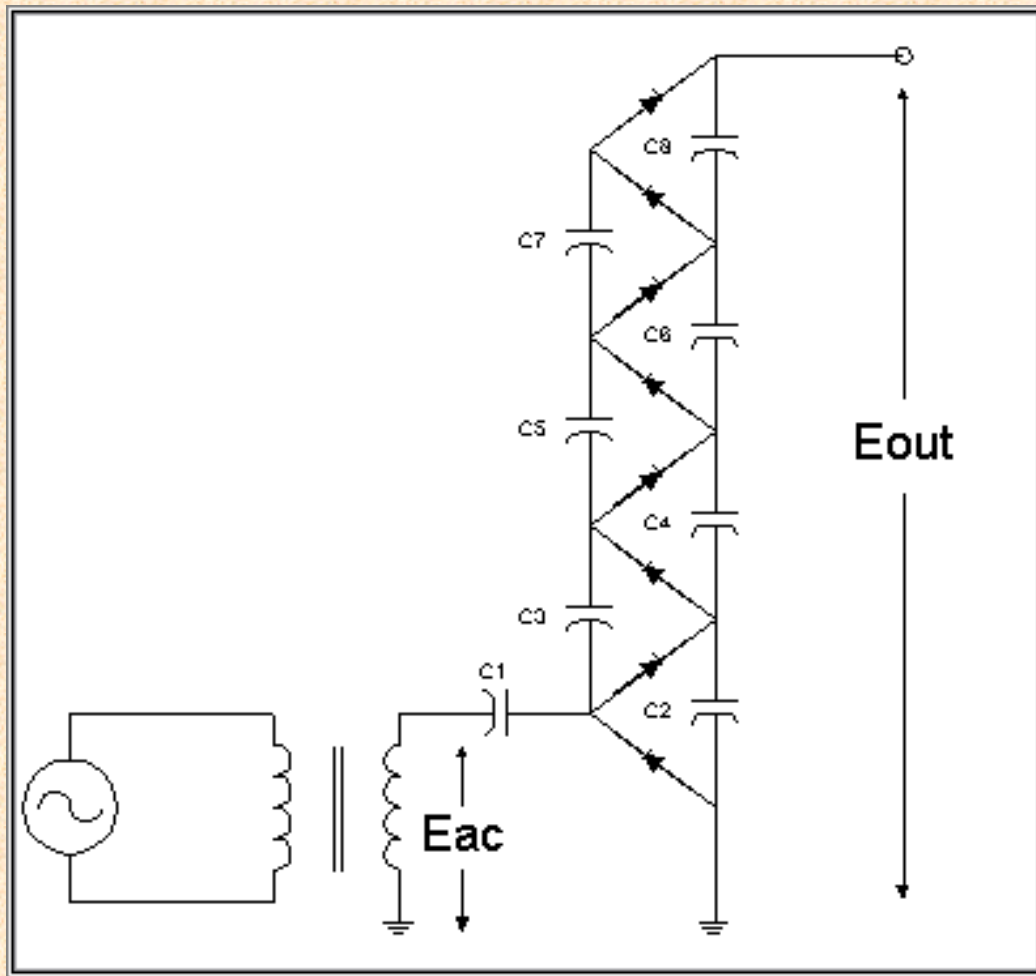
[Content on this page supplied with permission from this web site of Jim Lux](#)

Cockroft Walton Voltage Multipliers

The classic multistage diode/capacitor voltage multiplier, popularized by Cockroft and Walton, is probably the most popular means of generating high voltages at low currents at low cost. It is used in virtually every television set made to generate the 20-30 kV second anode accelerating voltage from a transformer putting out 10-15 kV pulses. It has the advantage of requiring relatively low cost components and being easy to insulate. It also inherently produces a series of stepped voltages which is useful in some forms of particle accelerators, and for biasing photomultiplier tube dynodes.

The CW multiplier has the disadvantage of having very poor voltage regulation, that is, the voltage drops rapidly as a function the output current. In some applications, this is an advantage. The output V/I characteristic is roughly hyperbolic, so it serves well for charging capacitor banks to high voltages at roughly constant charging power. Furthermore, the ripple on the output, particularly at high loads, is quite high.

It is quite popular for relatively low powered particle accelerators for injecting into another accelerator, particularly for heavy ions. The high ripple means that there is a significant energy spread in the ion beam, though, and for applications where low ripple is important at megavolt potentials, electrostatic systems like Van de Graaf and Pelletron machines are preferred.



The output voltage (E_{out}) is nominally the input voltage (E_{ac}) multiplied by the number of stages, 4 in the above diagram. However, in practice, the output is significantly lower, particularly with a large number of stages.

Regulation and ripple calculations

The voltage drop under load can be calculated as:

$$E_{drop} = I_l / (f \cdot C) * (2/3 \cdot n^3 + n^2/2 - n/6)$$

where:

I_{load} is the load current

C is the stage capacitance

f is the AC frequency

n is the number of stages.

The ripple voltage, in the case where all stage capacitances ($C1$ through $C(2 \cdot n)$) may be calculated from:

$$E_{ripple} = I_{load} / (f * C) * n * (n+1) / 2$$

As you can see from this equation, the ripple grows quite rapidly as the number of stages increases (as n squared, in fact). A common modification to the design is to make the stage capacitances larger

at the bottom, with $C_1 \text{ \& } C_2 = nC$, $C_3 \text{ \& } C_4 = (n-1)C$, and so forth. In this case, the ripple is:

$$\text{Eripple} = I_{\text{load}} / (f * C)$$

For large values of n (≥ 5), the $n^2/2$ and $n/6$ terms in the voltage drop equation become small compared to the $2/3n^3$. Differentiating the drop equation with respect to the number of stages gives an equation for the optimum number of stages (for the equal valued capacitor design):

$$N_{\text{optimum}} = \text{SQRT}(V_{\text{max}} * f * C / I_{\text{load}})$$

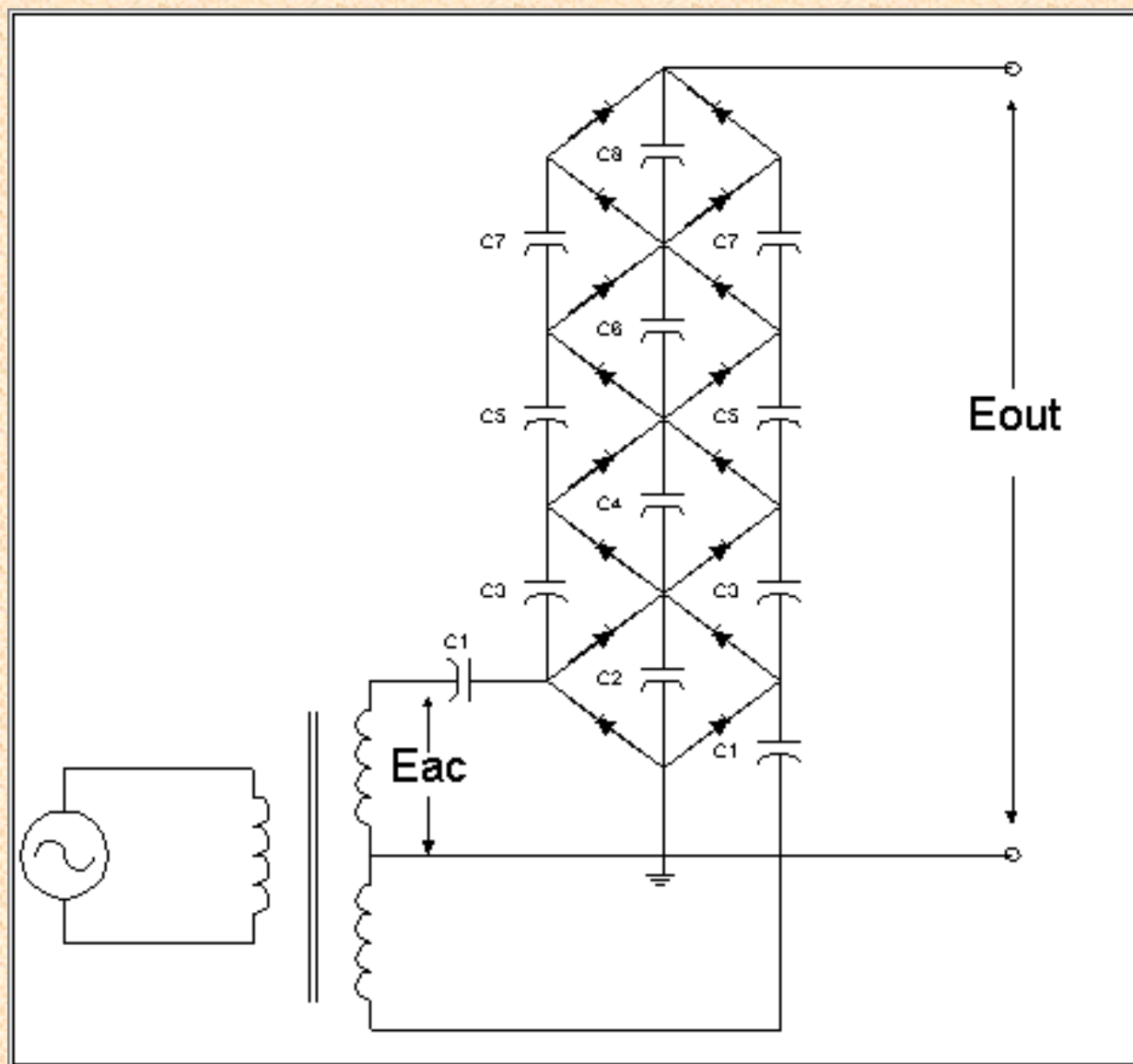
Increasing the frequency can dramatically reduce the ripple, and the voltage drop under load.

A modification to the basic Cockroft Walton multiplier

In some applications, an additional capacitor stack is connected to the output capacitor stack in the above design. This is particularly popular in electrostatic accelerator applications and high voltage x-ray systems, where low ripple desired.

Another modification to the basic Cockroft Walton design

A modification to the classic CW multiplier, popularized by XXX, uses two charging stacks driven by out of phase input voltages. This is particularly useful when the charging stack capacitors are significantly smaller than the output filter capacitors. The XXX modification is illustrated in the following figure.



Copyright 19987, Jim Lux / cw1.htm / 3 May 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)

SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

LOOK@ME?

UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
CLICK HERE

The word "SOLARIS" in a stylized, metallic, blocky font. The background is dark with blue and white lightning bolts.

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

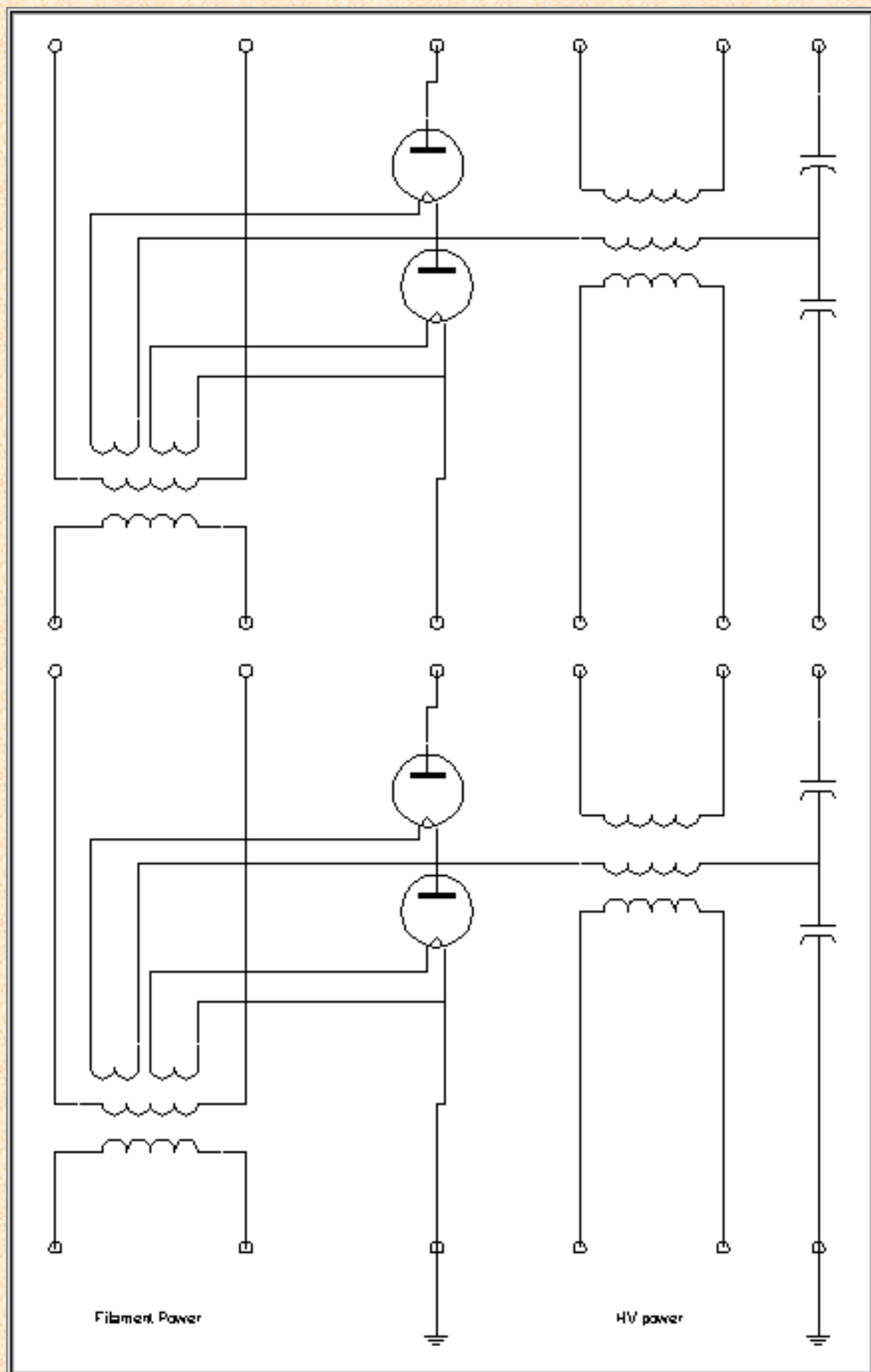
The text "ENERGY21" in a stylized, metallic, blocky font. The background is dark with blue and white lightning bolts.

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Examples of Cascaded Rectifier Systems

Charlton and Hubbard built a cascaded generator of 10 stages for precision X-ray measurement work in the range 400 kV to 1.4 MV. The overall system was 30.5 feet high with ten stages. Each 140 kV stage was a full wave rectifier (using kenotrons) with a pair of 0.1 μ F capacitors. It used the tertiary winding technique to pass the power to the stage above. The filament power was passed up the stack with same technique. The circuitry for two of the stages is shown in the following figure. Not shown in the schematic are reversing switches at each stage to reverse the polarity of the output.



Each of the ten identical stages was contained in an oil filled Herkolite tank 50 inches in diameter and 28.55 inches tall. The high voltage winding, 3 kVA at 66 kV RMS, was insulated for 70 kV at the capacitor end and 140 kV at the tube end. The filament transformer had all 4 windings insulated for 150 kVDC. The top terminal was a metal spinning 100 inches in diameter and 48 inches tall. The

corona current at 1.4 MV was only 0.16 mA. A 10.25 inch diameter tube was used as a conductor from the top of the stack to the top of the X-ray accelerator tube. 6 inch tubes were used for the taps.

The following table gives the load characteristics at 1.4 MV.

Load Current (mA)	Input V	Input A	kW	Power Factor	% efficiency
0.16	148	23.6	1.81	0.52	
1.0	159	46.9	4.40	0.59	35
2.0	166	54	5.83	0.65	48
5.0	180.5	80	10.95	0.757	64
10.0	192	120	19.35	0.84	72.3
15.0	200	158	27.50	0.87	76.5

Another similar system was built by Koch and Sterzel in 1940 to reach voltages of about 900 kV. It used 4 stages, with capacitors of 0.22 μ F and Siemens-Reiniger rectifiers rated at 320 kV max inverse voltage. The heaters were powered by generators driven by a shaft from the ground. This system used the scheme of highly insulated isolation transformers to send the power up the stack, and separate HV transformers feeding the rectifiers. The individual rectifiers were eventually replaced by a series of rectifiers all in a common vacuum stack which was continuously pumped. Each of these rectifiers had an internal resistance of 30-60 kOhm and a filament current of 9.5 A provided a saturation current of 100 mA. The system was also modified to allow its use as a 2MV Marx Generator, and for AC output, as well.

The Phillips company developed a technique of passing the heater current up the stack through capacitors at high frequencies.

Modern systems of this type tend to use air or ferrite cored transformers, and modern switching type power supplies to excite the bottom stage. And, of course, semiconductor rectifiers are almost universally used, since they eliminate the need to pass heater power up the stack. Vacuum tube rectifiers do have the advantage of better immunity to transients and momentary overloads. However, the cost difference of \$10 for a 40 kV semiconductor rectifier and \$100 for an equivalent vacuum tube becomes significant when 10 or 20 stages are contemplated.



ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

A horizontal banner with a dark background and a blue lightning bolt pattern. The word "SOLARIS" is written in a large, metallic, blocky font on the left side.

THE SEARCH FOR NATURES
ABUNDANT ENERGY SECRETS

A horizontal banner with a dark background and a blue lightning bolt pattern. The text "ENERGY21" is written in a large, metallic, blocky font on the left side, with the "21" in red.

DISCOVERING NATURES POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Pelletron

The Pelletron (a tm of National Electrostatics Corp) is a much improved form of the Van de Graaf generator. It uses a chain of conductive pellets separated by insulating links to replace the belt of a Van de Graaf. The chain allows much higher charging currents and is mechanically more rugged, particularly with respect to sparking. Pelletron actually refers to a whole series of electrostatic accelerators built by NEC with a number of improvements beyond the charging system, like the accelerator tubes, pumping systems, insulation and mechanical structures, etc.

Pelletron usage has greatly increased in the last few decades with materials science applications being quite popular.

A review paper on Pelletrons (by the man who invented them) is: Herb, R.G. "Pelletron Accelerators for Very High Voltage", *Nuclear Instruments and Methods*, v. **122**, pp 267-276, 1974

And of course, another resource would be the manufacturer: [National Electrostatics Corporation](#)

Relevant patents are:

TBD

Copyright 1997, Jim Lux/ pelletro.htm / [Back to High Voltage Main Page](#) / [Back to home page](#) / [Mail to Jim](#) (jimlux@earthlink.net)

A horizontal banner with a dark background and a blue lightning bolt pattern. The word "SOLARIS" is written in a large, metallic, blocky font on the left side.

THE SEARCH FOR NATURES
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

The banner features the word "SOLARIS" in a bold, metallic, sans-serif font. The background is dark with stylized white lightning bolts.

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

The banner features the text "ENERGY21" in a bold, metallic, sans-serif font. The background is dark with stylized white lightning bolts.

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Tesla Coils

Invented by Nikola Tesla in the 19th century, and much beloved of science fiction film makers of the 30's and 40's, as well as hv experimenters of today, the Tesla coil is an inexpensive way to generate very high voltages (megavolts) at radio frequencies. A tesla coil consists of an air core inductor that acts as a quarter wave transmission line shorted at one end and open at the other. The shorted (low impedance) end is driven by link coupling from a high power RF source at the resonant frequency of the transmission line. The impedance transformation of the quarter wave line turns the high current, low voltage at the shorted end to very high voltage, low current at the open end. The most popular RF source is a resonant LC circuit excited by an impulses created by a spark gap.

There is an immense amount of information on Tesla coils available on the web, some of it good, some of it positive dreck. Start with [Bill Beatty's page](#) at www.eskimo.com/~billb/.

Copyright 1997, Jim Lux / [Back to home page](#) / [Mail to Jim](#)



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
CLICK HERE



[Content on this page supplied with permission from this web site of Jim Lux](#)

Using multiple transformers to get more high voltage power.

Neon sign transformers

Like a lot of experimenters, I started with a neon sign transformer as a high voltage source. Common neon sign transformers cost about \$80 and put out about 15kV (no load) and around 30 mA shorted, although you can get lower voltages and currents easily. You can also get bigger transformers, however, they are special order, and are more expensive. Furthermore, they have more current output, but the voltages stay in the same 15 kV range. In the neon sign business, there just isn't much call for higher voltages. Also, the standard wire that signs are wired with is rated to 15 kV, providing a nice 2:1 safety margin, since the center of the transformer secondary is grounded (so it really puts out only 7.5 kV relative to ground).

A neon sign transformer limits the current by its construction with a high leakage inductance, which essentially puts an inductor in series with the transformer. The impedance of the series inductor serves to limit the current, while not dissipating much power (as a resistor would). This is desirable when running a discharge tube, because the tube has a negative V/I characteristic, and if driven from a stiff voltage source, it would draw more and more current until either the tube or the transformer melted down. The same technique for current limiting is used in arc welders, although at a somewhat lower voltage and a lot more current.

However, we all want more voltage or current. Let's look at voltage first. You could just increase the primary voltage, which will raise the secondary voltage in proportion. There are two basic limits to this approach. The first is that the insulation on the transformer isn't necessarily good to much over the nominal voltage. They have already gone to the expedient of grounding the centertap to reduce the voltage requirement. You might get to 20-25 kV before you started having problems. The second problem is core saturation. They don't design transformers with a lot of extra iron, because it is expensive and heavy. As you increase the voltage, you need more area in the core to keep the flux density below the saturation level for the iron. If the core saturates, you draw more power, but it essentially all goes into heat. You can see this if you hook a 0-240V autotransformer up to just about any 110V transformer, and gradually increase the voltage while monitoring the output voltage at no load. Around 150-160V, the output voltage stops rising proportionately, and if you look at the

waveform on a scope, it becomes quite distorted.

Now let's look at current. What limits the current is that series inductance. In theory, you can put in a capacitor of equivalent impedance (although opposite in sign, of course), which will allow more current to flow. The problem with this has to do with cost and availability. Say your neon transformer is rated at something like 400 VA, i.e. it draws a short circuit current of around 4 Amps. The equivalent series reactance providing the current limiting is about 25 ohms, or about 60 mH. A capacitor to just cancel this would also be 25 Ohms, or about 100 uF. The real problem, though, is that the transformer is designed to run at a particular power, and if you increase the current, you increase the heating from the I^2R losses and core losses. Draw twice the current, and you have 4 times the heating, which will probably melt the insulation.

Well, what about hooking up multiple transformers in series or parallel? You can hook up multiple transformers in parallel to increase the current, although at some point, it is cheaper to just get a bigger transformer. If you are buying new, this is certainly true: a transformer of twice the rating costs less than twice as much, and is more efficient to boot. However, if you are buying surplus (typically 10%-20% of new price), you have to work with what you have got. When hooking up parallel systems, make sure that parallel outputs are properly phased. There are also some potential problems if the transformers are not exactly identical, particularly with respect to series impedance (they will probably all have the same turns ratio). There are some tricks using an additional smaller transformer to balance multiple paralleled transformers.

[Theory behind this scheme](#)

What about hooking up transformers in series to get more voltage. The problem here goes back to insulation and grounding. A neon transformer has the secondary centertap grounded to the case, so the insulation from the secondary winding high voltage end needs only withstand the 7.5 kV. If you remove this ground, you might arc to the case (not so bad, as long as the case is isolated) or much, much worse, arc to the primary side (actually more likely). Then, you are feeding kilovolts back into your power line, a bad situation in any case.

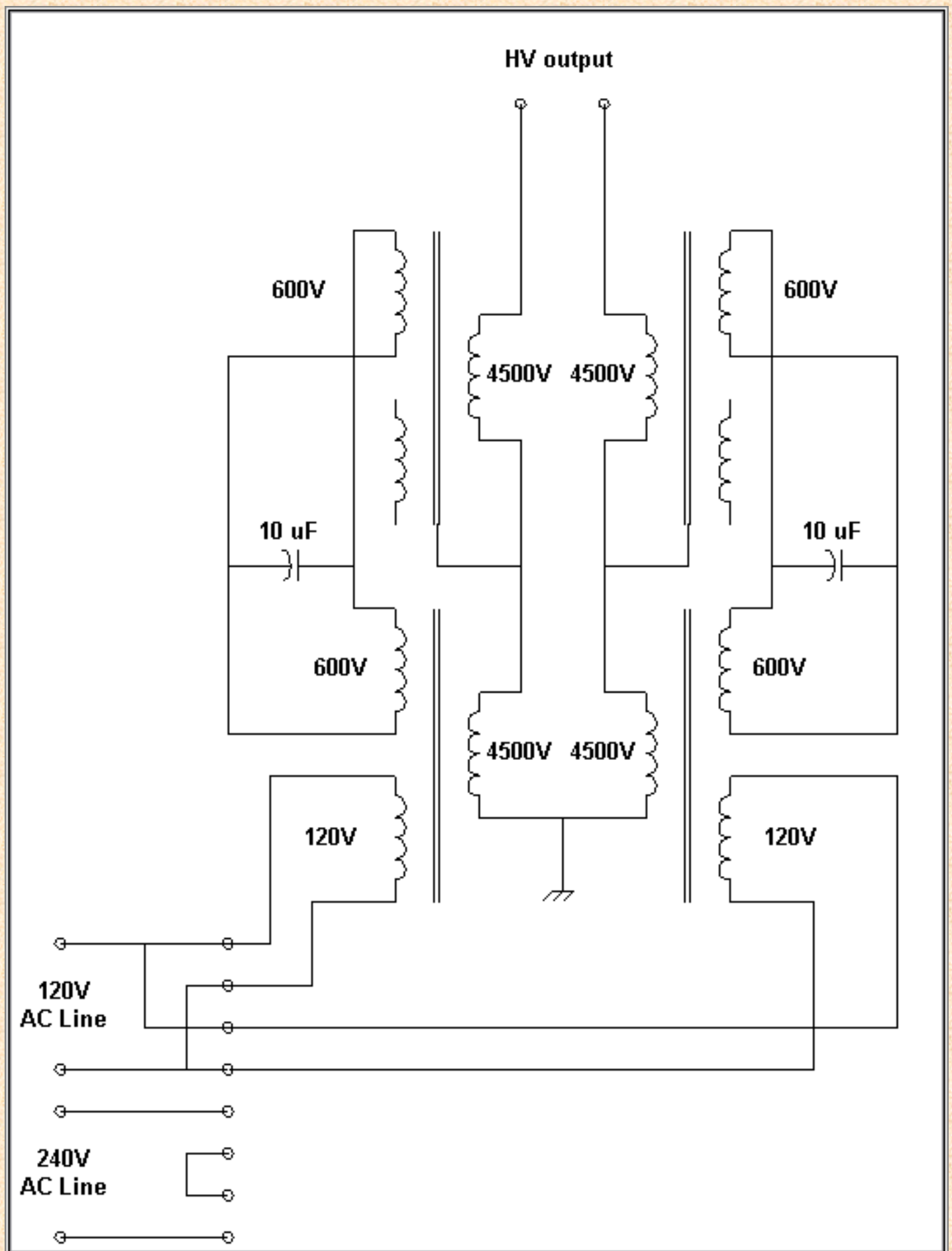
If you have a cheap source for isolation transformers that can take many kV, you could run one transformer grounded, then run the other through the isolation transformer, and successfully series them. Isolation transformers like this turn up in surplus sometimes, they are used to power 110V lights and such that float at high voltage (like tower lights on transmitting antennas) or to run small motors or relays which are sitting at high voltage line potential. Unfortunately, they are typically around 500-1000 VA, and so are not suitable for high power systems (unless you have a lot of bucks, or the transformers are very cheap).

There is a solution, however. Assume a transformer with 3 windings: the 110V primary, the HV secondary, and another 110V tertiary. Also assume that the insulation of the transformer is such that the two 110V windings can take the full secondary voltage. If this is the case, then you can feed a second transformer from the first, essentially using the first transformer as a isolation transformer. The primary of the second is fed from the tertiary of the first. You can, of course, extend this ad infinitum, feeding a third transformer from the tertiary winding of the second, etc.

The limitation is that the primary of the first transformer must carry the entire power of the chain of transformers, so those primary and tertiary windings have to be pretty good sized. For instance, if you had a chain of 10 transformers, each putting out 10 kV at 100 mA (i.e. 1 kVA), the primary of the first one in the chain has to handle 100 Amps: 10 Amps for the power to the HV secondary, and 90 Amps to the tertiary winding. The second stage handles 90 Amps: 10 to the HV secondary of this stage, and 80 to the next, and so on.

It so happens that C&H Sales sells the aforementioned illumination transformer which conveniently has a tertiary winding. The basic specs of the transformer are: 110V primary at 8 Amps, 4500 V secondary @ 450 mA, and a tertiary winding at 600 V. This is a transformer designed to run a discharge tube, so it was designed with leakage inductance to limit the current: you can short the output and the transformer doesn't overheat or overload. The 600 V winding is designed to connect to a 10 uF cap, which provides a measure of power factor correction so that the power line doesn't see the highly inductive nature of the transformer. The designers did this because 10 uF, 600V caps are readily available and cheap, as opposed to the 3600uF 110V cap that would have been necessary if you just tried to do the PF correction with a parallel cap.

So, we can hook up a second one of these transformers by running the 600 Volts out of the first one into the 600 Volts of the second one. We leave the 110V primary of the second transformer unconnected and connect the 4500V secondaries in series. The second transformer core is connected to the low side of its secondary so that it runs at some known voltage, as opposed to whatever capacitive coupling would get it to. And, of course, it has to be mounted on insulating standoffs of some sort. Now we have a 9000 Volt 225 mA transformer. The leakage inductance of the first transformer of the chain limits the current into it, which effectively is divided between the two.



We can hook up another pair of these transformers, phased exactly opposite, with the primaries in parallel, to get a 18 kV center-tap grounded transformer at 225 mA, or, an 18kV, 225 mA neon transformer. It draws about 16 Amps with the output shorted.

This unit, although a bit heavy, produces very nice fat sparks in jacob's ladder type systems. The diameter of an arc is determined by the square root of the current (i.e. the current density of an arc is roughly constant), so the 10 fold improvement in current gives you an arc some 3-4 times larger than the typical 30mA neon transformer. All this for about \$200 in transformers, and some insulating standoffs and chassis work. I should mention that the chassis work is pretty important, since you are going to wind up with about 200 pounds of transformers. I built mine on a sheet of aluminum that was bolted to a hand truck with wheels. You could also build it inside a milk crate or something like that.

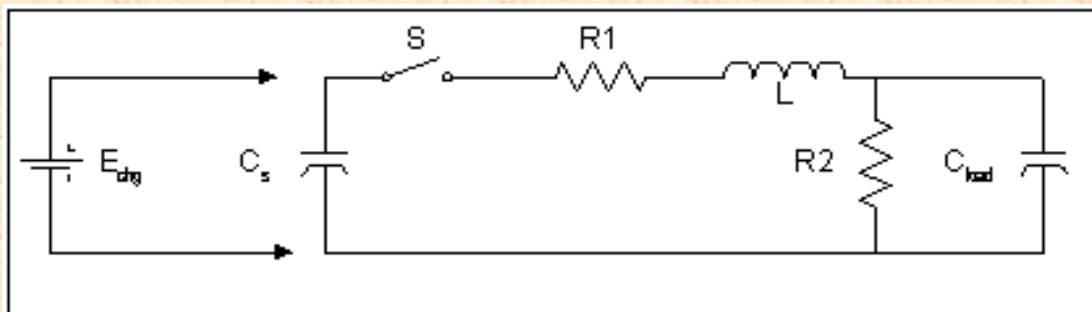


SOLARISTHE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS**ENERGY21**DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Capacitor Discharge Impulse Generators

This is the simplest means of generating a high voltage impulse in a load. Practical considerations usually dictate that more sophisticated means be used (like [Marx generators](#), Transmission line pulse formers, Impulse transformers, etc.), but the basic capacitor discharge circuit is a good place to start.



The circuit above has all the essential components:

Echg - A means of charging the capacitor. Often, either a current limited HV power supply and a switch to connect it to the capacitor, or a HV power supply and a large series resistor to limit the charging current.

C_s - A capacitor to store the energy.

S - A switch to apply the energy to the load

$R1$ and L Series resistance and/or inductance, either parasitic or added for pulse shape control

$R2$ - Load resistance

C_{load} - Load capacitance

Waveforms and the effect of resistances and inductances

Assuming the parasitic inductances are small (often, this is not a valid assumption), the output of a capacitive impulse generator can be represented by a pair of exponentials, reflecting the charging of the load capacitance and then, the discharge of the storage and load capacitance. The most common way to describe the waveform is by its rise and fall times.

A standard waveform for lightning impulse testing would be a 2/50, where the load voltage reaches its peak in 2 microseconds, and the decay to half the peak voltage takes 50 microseconds.

Energy Discharge Capacitors

In these systems, the capacitor is used to store the energy to be used for the impulse. Since fast rise times are usually desired, the capacitor should have low parasitic inductance. Resistive losses also result in lower efficiency and slower rise times. Commercial energy storage capacitors are designed to a specific capacitance. The manufacturer then tests them, and their actual characteristics (capacitance, stored energy) are marked on the label.

Switches

The switches for an impulse generator fall into two general categories. The first is those that are primarily mechanical in nature, consisting of contacts that are closed by some means such as a spring, solenoid, air cylinder, or other actuator. The second is those that have no moving parts, with the triggered spark gap being very popular, although in some applications, devices such as thyratrons or SCR's are used.

Capacitor Charging considerations

The rectified output of a high voltage transformer is probably the simplest system used for charging the capacitor. Some form of current limiting is necessary because the capacitor looks like a dead short when fully discharged. The current limiting is often in the form of a series impedance. The impedance can be either inductive or resistive and can either be in the primary side of the transformer or the secondary (or be in sort of both, in the form of leakage inductance in the transformer).

A resistive current limiter is simple, but the energy dissipated in the resistor is significant, being equal to the stored energy in the capacitor. Inductive current limiters don't have the power dissipation problem of a resistor, but are more susceptible to unwanted resonance effects, particularly with parasitic reactances. A resonant charging scheme using a diode and an inductor is very popular for capacitor discharge circuits that are fired repeatedly.

Fruengel recommends the use of a voltage multiplier (Cockroft-Walton type), because it has a hyperbolic voltage/current characteristic that lends itself to capacitor charging. The disadvantage is that there is significant stored energy in the capacitor stack of the multiplier, although raising the

input frequency reduces the size of capacitor required, and the stored energy. In fact, a logical outgrowth of this trend is the use of switching power supplies.

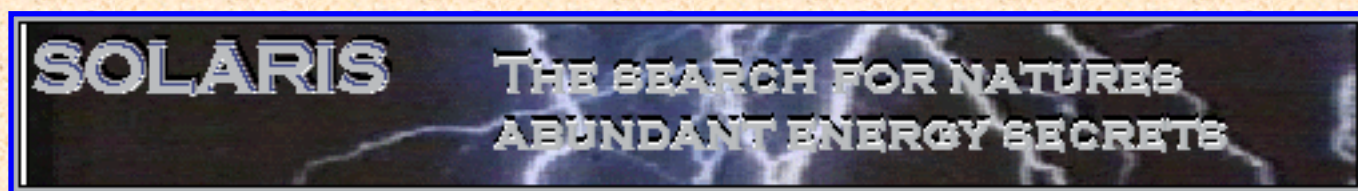
Switchers as capacitor chargers

In recent years, switching power supplies have become popular for capacitor charging. The generally high (tens of kHz) switching frequency reduces the stored energy in the supply, which enhances safety and reduces the chances of a flashover arc developing. They can provide a constant charging current, reducing the power lost compared to a series resistor RC scheme. They can also detect faults and shut down the supply if an arc develops or a capacitor fails (shorted) during charging. HV power supply manufacturers such as Maxwell have power supplies designed specifically for charging capacitors.

Watch out for voltage reversals during discharge

The system for charging should take into account the voltage reversal on the storage capacitor if any. For instance, a current limited HV transformer feeding a bridge rectifier is a convenient way to charge a capacitor. However, if the capacitor discharge waveform has any voltage reversal, the diodes in the bridge will be forward biased in parallel with the capacitor, and the resulting high peak currents will most likely destroy the diodes.

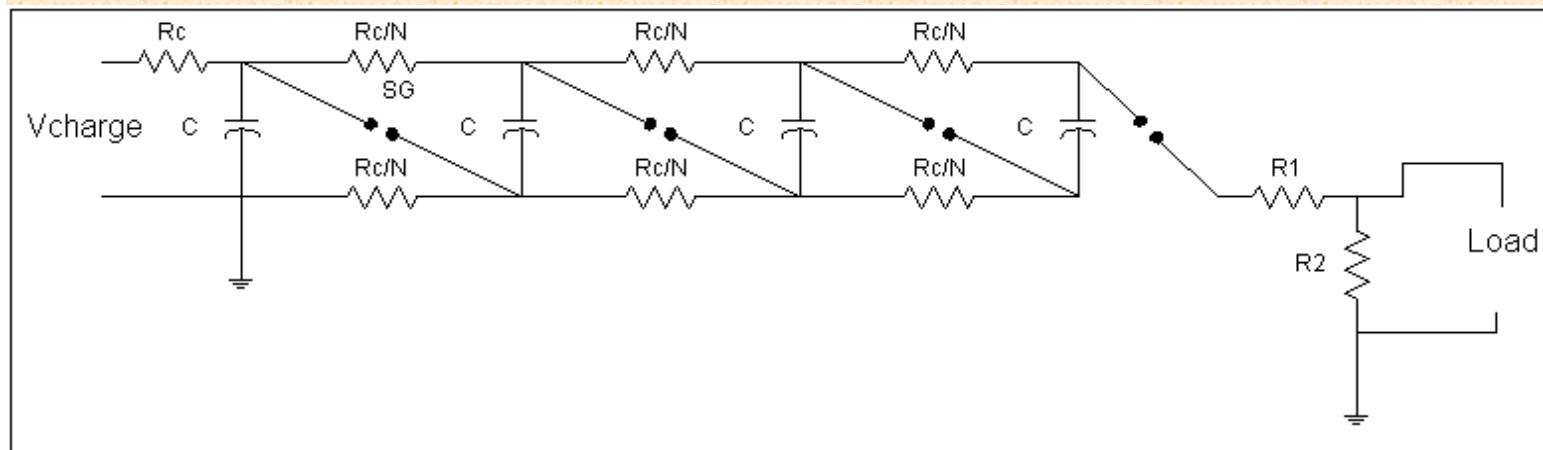
Copyright 1998, Jim Lux / cdimp.htm / 3 May 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



[Content on this page supplied with permission from this web site of Jim Lux](#)

Marx Generators

A Marx Generator is a clever way of charging a number of capacitors in parallel, then discharging them in series. Originally described by E. Marx in 1924, Marx generators are probably the most common way of generating high voltage impulses for testing when the voltage level required is higher than available charging supply voltages. Furthermore, above about 200 kV, the discharge capacitor becomes very expensive and bulky. The [Fitch](#) circuit is becoming popular where very good control over impulse voltage is required.



How it works

The charging voltage is applied to the system. The stage capacitors charge through the charging resistors (R_c). When fully charged, either the lowest gap is allowed to breakdown from overvoltage or it is triggered by an external source (if the gap spacing is set greater than the charging voltage breakdown spacing). This effectively puts the bottom two capacitors in series, overvoluting the next gap up, which then puts the bottom three capacitors in series, which overvolutes the next gap, and so forth. This process is referred to as "erecting". A common specification is the erected capacitance of the bank, equal to the stage capacitance divided by the number of stages.

The charging resistors are chosen to provide a typical charging time constant of several seconds. A typical charging current would be in the 50-100 mA range. The charging resistors also provide a current path to keep the arc in the spark gaps alive, and so, should be chosen to provide a current of 5-10 amps through the gap. The resistors are sometimes called "feed forward" resistors for this reason. The discharge through the charging resistors sets an upper bound on the impulse fall time, although usually, the impulse fall time is set by external resistors in parallel with the load (or integrated into the generator, as described below).

For example, with a stage voltage of 100 kV, a desired output voltage of 1 MV (i.e. 10 stages), the charging resistors should be about 20-40 kOhms (corresponding to an arc current of 5 to 10 Amps). If the capacitors were 1 uF, then the discharge time constant would be 20 milliseconds, much, much longer than the 50 microsecond time constant of the standard test impulse. This example generator would have a stored energy of 5 kJ/stage or 50 kJ for the total system. At a charging current of 50 mA, it would take at least 20 seconds to charge the entire stack.

If a constant voltage charging source is used, significant energy is dissipated in the charging resistors, equal to the stored energy in the capacitors.

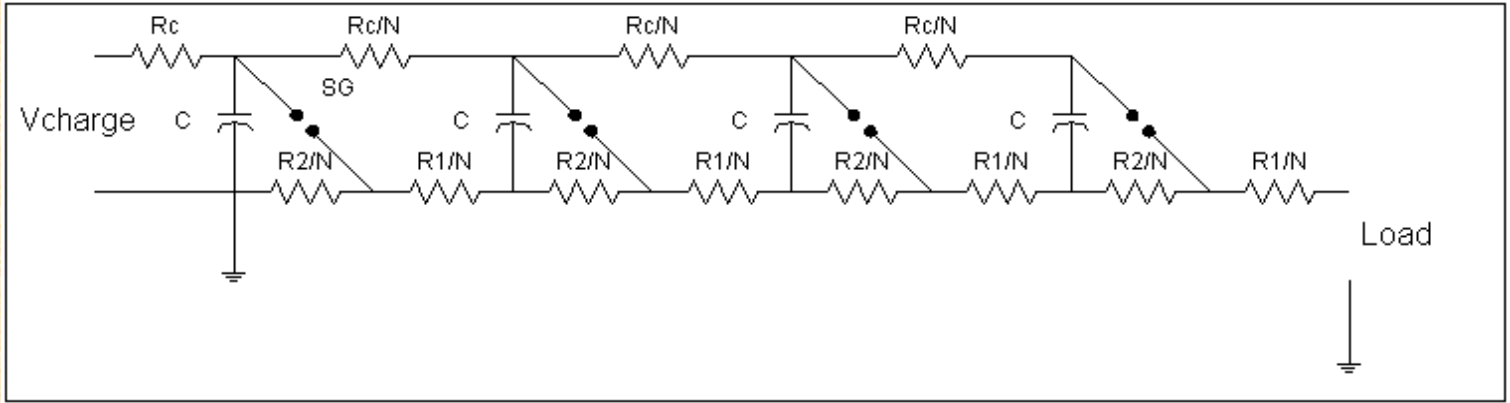
Design enhancements and considerations

Charging with a constant current source

If the Marx generator is charged from a constant voltage source, the energy dissipated in the charging resistors will be equal to that stored in the Marx capacitors. If the bank is charged with a constant current source, this energy loss can be substantially reduced.

Integrating the waveshaping resistors into the generator

In the classic capacitor discharge impulse generator, the shape of the pulse is controlled by external impedances (usually resistors) at the "output" of the pulse generator. As voltages get higher, it gets harder to build practical resistors with low parasitic inductance that will also withstand the full impulse voltage. The usual remedy for this is to include the wave-shaping resistors in the Marx bank itself, as illustrated in the following figure.



Reducing the jitter

If the gaps in the Marx generator don't all fire at exactly the same time, the leading edge of the impulse will have steps and glitches as the gaps fire. These delays also result in an overall longer rise time for the impulse. If the jitter in the gaps is reduced, the overall performance is improved.

The traditional Marx generator operating in air has all the gaps in a line with the electrodes operating horizontally opposed. This allows the UV from bottom gap to irradiate the upper gaps, reducing their jitter. Tests reported in Craggs and Meek showed that obstructing the UV led to greatly increased jitter in the bank output, which they attribute to the lack of UV irradiation on the upper gaps.

For a Marx generator which is immersed in oil, or using enclosed spark gaps, resistor or capacitor networks can be used to propagate the trigger pulse to all the gaps, rather than relying on the overvoltageing of the upper gaps to fire them.. A design from Maxwell labs uses a series of resistors to apply the trigger impulse to all the gaps.

Laser irradiation or triggering of the gaps could also be used.

Craggs and Meek also report the use of radioactive sources included within the gap electrodes to reduce the jitter.

Other switching devices

The Marx technique has been used to generate impulses of several kilovolts from a relatively low charging source using avalanche transistors as the switching device instead of a spark gap. In this case, the resistors need to be chosen to keep the transistor turned on.

Alternate charging schemes


Particularly for lower output voltages, the capacitors can be charged in parallel from a common source through a series resistor or inductor. The charging impedance has to withstand the full output voltage for the top stage. For the solid state Marx generator running at a few kV described above, this isn't as much of a problem as it would be for a megavolt range lightning impulse simulator.

Inductors as the charging impedances


The charging resistors can be replaced by inductors, eliminating the power loss in the resistors.

Increasing the repetition rate by using Hydrogen spark gaps


Hydrogen has a very fast recovery time, facilitating the production of high rep rate pulses from a Marx circuit. An example of this is a design by Grothaus, Moran and Hardesty, shown in U.S. patent [#5311067](#). This is a very compact pulser running in a pressure tank filled with hydrogen.



THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS



DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
CLICK HERE

SOLARIS

THE SEARCH FOR NATURE'S ABUNDANT ENERGY SECRETS

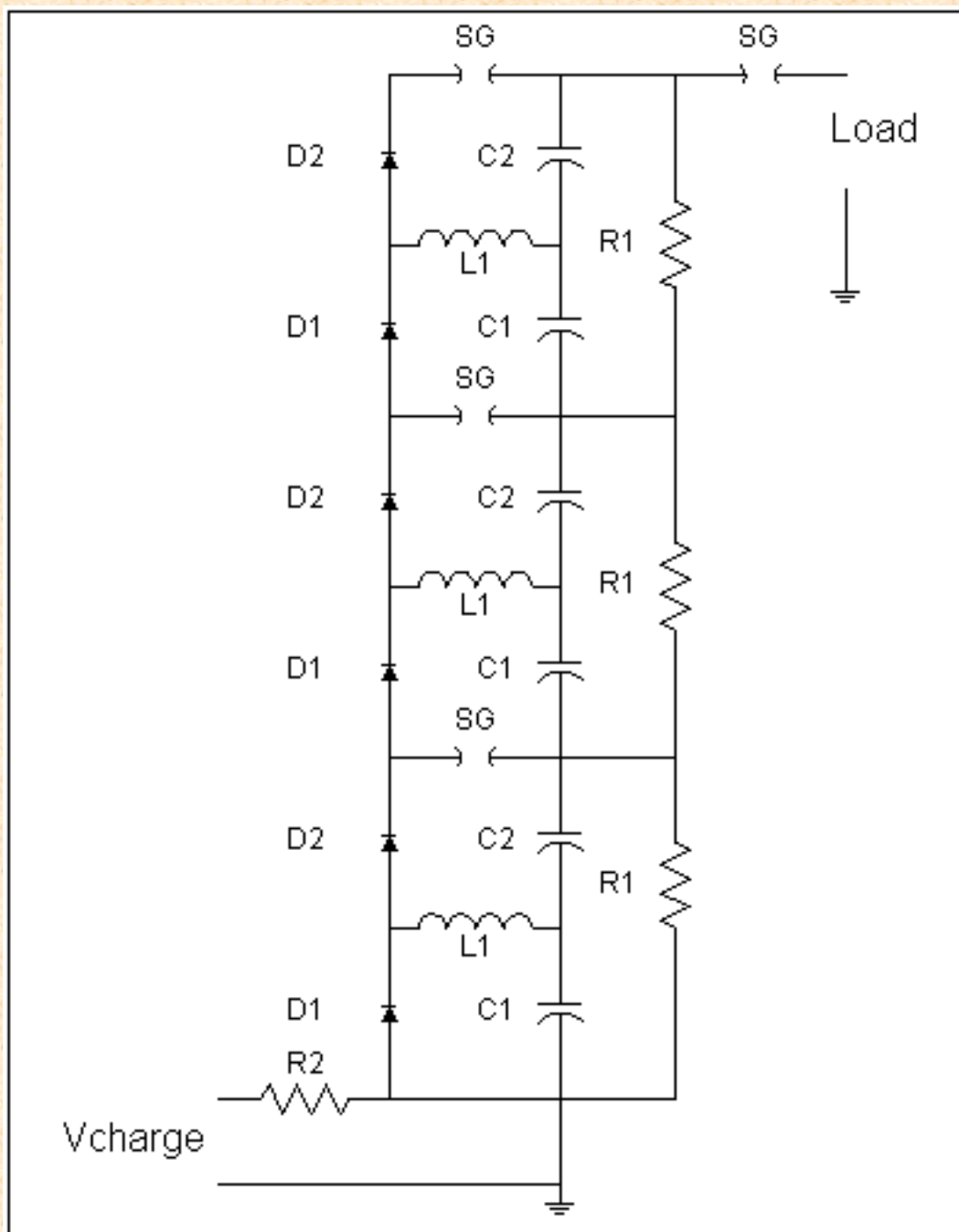
ENERGY21

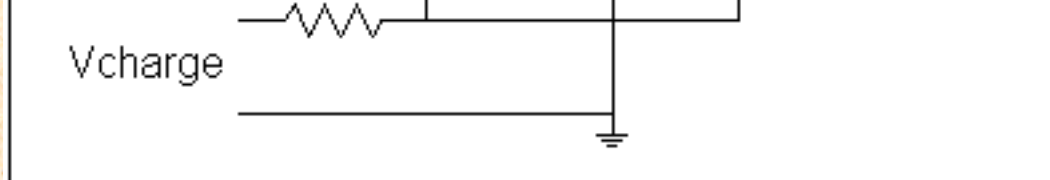
DISCOVERING NATURE'S POWER SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Fitch Impulse Generators

The Fitch circuit is used when better control of the impulse voltage is required than can be provided by the [Marx](#) circuit.





Copyright 1998, Jim Lux / [fitch.htm](#) / 3 May 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



The word "SOLARIS" in a stylized, metallic, blocky font.A dark banner with a blue and white lightning bolt pattern in the background.

THE SEARCH FOR NATURES
ABUNDANT ENERGY SECRETS

The word "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.A dark banner with a blue and white lightning bolt pattern in the background.

DISCOVERING NATURES POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Tailbiter circuits for generating square pulses

One technique for generating a square pulse is to use a fast acting switch to shunt the output of a pulse generator that is making a longer pulse: that is, biting off the tail of the impulse. The impulse generator can be almost any sort that generates a pulse with an appropriate duration that is sufficiently flat. The switch can be a triggered spark gap, a triggered gas discharge tube (e.g. Thyatron), or even a semiconductor switch for lower voltages. In general, the stored energy from the impulse generator is dissipated in the shunt switch.

Another technique, more difficult of implementation, uses a series switch that turns off in mid-impulse. Fast switches that turn off with high voltages and currents are harder to come by, although for a few tens kV, strings of semiconductors or vacuum tubes can be used.

A popular application for tailbiters is for controlling the amount of light emitted by an electronic flash. The shunt switch across the flashtube is triggered when an integrating light detector reaches the desired exposure, dumping the remainder of the stored energy and quenching the main flash tube. In early versions of this circuit, a second flash tube was used as the switch, although more recently, various thyristors are more popular.

A series tailbiter using a high voltage MOSFET switch is becoming common now, having the advantage that the excess stored energy is retained, instead of dissipated in the shunt switch.

Copyright 1998, Jim Lux / tailbite.htm / 8 March 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)

The word "SOLARIS" in a stylized, metallic, blocky font.A dark banner with a blue and white lightning bolt pattern in the background.

THE SEARCH FOR NATURES
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

The banner features the word "SOLARIS" in a bold, metallic, sans-serif font. The background is dark with a bright, jagged lightning bolt striking from the top right towards the center.

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

The banner features the text "ENERGY21" in a bold, metallic, sans-serif font. The background is dark with a bright, jagged lightning bolt striking from the top right towards the center.

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Sphere Gaps

A spark gap will have a very repeatable breakdown voltages for a given atmospheric conditions. For mostly mechanical reasons, uniform field gaps (using, for example [Rogowski](#) or [Bruce](#) profile electrodes) are not used as much as sphere gaps where the spheres are quite a bit larger than the gap. There isn't a convenient analytical expression for the breakdown voltage as a function of sphere diameter and gap, as there is for a uniform field gap, however, there is a lot of empirical test data, and sphere gaps are by far and away the most common way of measuring high voltages with a spark gap.

Typical accuracies are 3% for gaps less than half the diameter of the sphere and 5% for the gap larger than the diameter of the sphere. As the gap gets larger, the field between the spheres gets more and more nonuniform, and as a result the scatter in the data gets larger. A [rod gap](#) represents sort of the ultimate in non-uniform gap, and is often quoted at +/- 8% accuracy.

[Breakdown Voltage Table](#)

Mechanical and electrical details

A series resistor is usually put between the source and the gap to limit the breakdown current and to provide some damping of the high frequency oscillations. It is typically 100K to 1 Meg for AC or DC voltages, and no more than 500 Ohm for impulse voltages.

For AC peak and DC measurements, the voltage is gradually increased until breakdown occurs. The mean of 5 measurements that fall within $\pm 3\%$ is used as the value.

Sphere gaps can be arranged either vertically, typically with the lower sphere grounded (earthed), or horizontally. The surroundings do have an effect on the breakdown voltage, as they alter the field configuration. Standard clearances are specified for spheres of various sizes in both configurations. These clearances reduce the effect of the surroundings to less than the specified accuracy (e.g. 3%). In the following: D is the diameter of the spheres, S is the spacing of the gap, $S/D \leq 0.5$.

A is the height of the lowest point of the HV sphere above the ground. B is the radius of clearance from surrounding structions.

<u>D (cm)</u>	<u>A (max)</u>	<u>A (min)</u>	<u>B (min)</u>
<= 6.25	7*D	9*D	14*S
10-15	6*D	8*D	12*S
25	5*D	7*D	10*S
50	4*D	6*D	8*S
100	3.5*D	5*D	7*S
150	3*D	4*D	6*S
200	3*D	4*D	6*S

Actual values (meters)

Sphere Diameter (cm)	A (max) meters	A (min) meters	B (min) for max gap (D/2) meters
<= 6.25	7*D	9*D	14*S
10-15	60-75	0.80-1.20	0.60
25	1.25	1.75	1.25
50	2.0	3.0	2.0
100	3.5	5.00	3.5
150	4.5	6.00	4.5
200	6.0	8.00	6.0

Additional Construction details

The insulator supporting the upper sphere should be less than 0.5 D in diameter. The sphere itself should be supported by a conductive metal shank no more than 0.2 D in diameter and at least D in length (that is, the sparking point should be at least 2D from the lower end of the upper insulator).

The high voltage lead should not pass near the upper electrode.

The top of the lower electrode should be at least 1.5D above the (presumably) grounded floor.

Horizontal gaps are much the same as vertical gaps, except that both electrodes are insulated. The insulators should be longer, at least 2D long (putting the sparking point at least 4D from the supports: 2D for the insulator, 1D for the shank, 1D for the sphere). And, both spheres should be the appropriate clearance from the floor or external objects.

SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

SOLARIS**THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS****ENERGY21****DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND**

[Content on this page supplied with permission from this web site of Jim Lux](#)

Sphere Gap Breakdown Voltage Tables

The following two tables give the breakdown voltages for a standard sphere gap of the specified sphere size and spacing. The standard accuracy is $\pm 3\%$ for gaps less than half the sphere diameter and 5% for gaps larger than that. The first table is for a gap with one terminal grounded, typically a vertical gap. There are two columns for each sphere size depending on whether it is a positive or negative impulse. The second table is for a gap with both terminals at HV. The values from these tables will need to be corrected for current atmospheric conditions, particularly humidity.

A -> AC, DC, either polarity and full negative standard impulse voltages (one sphere grounded)

B -> positive polarity standard impulse voltages and impulse voltages with long tails (either polarity)

Gap Spacing	5	5	10	10	15	15	25	25	50	50	100	100	150	150	200	200
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
0.5	17.4	17.4	16.9	16.8	16.9	16.9										
1	32	32	31.7	31.7	31.4	31.4	31.2	31.4								
1.5	44.7	45.5	44.7	45.1	44.7	45.1	44.7	44.7								
2	57.5	58	58	58	58	58	58	58								
2.5			71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5						
3			85	85	85	85	85	85	85	85						
3.5			95.5	96	97	97	97	97	97	97						
4			106	108	108	110	110	110	110	110						
5			123	127	127	132	135	136	136	136						
7.5					181	187	195	196	199	199						
10							257	268	259	259	262	262	262	262	262	262
12.5							277	294	315	317						
15							309	331	367	974	383	384	384	384	384	384
17.5							336	362	413	425						
20									452	472	500	500	500	500	500	500

[illegible]

gap (cm)	5	10	15	25	50	100	150	200
0.5	17.5	16.9	16.5					
1	32.2	31.6	31.3	31				
1.5	46.1	45.8	45.5	45				
2	58.3	59.3	59.2	59				
2.5	69.4	72.4	72.9	73				
3	79.3	84.9	85.8	86				
4		107	111	113	112			
5		128	134	138	138	137	137	137
8		177	194	207	214			
10				248	263	266	267	267
12				286	309			
14				320	353			
16				352	394			
18					452			
20					495	504	511	511
25					558	613	628	632
30						744	741	746
35						812	848	860
40						902	950	972
50						1070	1140	1180
60						1210	1320	1380

70
80
90
100

1490	1560
1640	1730
	1900
	2050



THE SEARCH FOR NATURES
ABUNDANT ENERGY SECRETS



DISCOVERING NATURES POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
CLICK HERE

The banner features the word "SOLARIS" in a bold, metallic, sans-serif font. The background is dark with stylized white lightning bolts.

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

The banner features the text "ENERGY21" in a bold, metallic, sans-serif font. The background is dark with stylized white lightning bolts.

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Rod Gaps

The standard rod gap uses two long rods (usually square in cross section, but round can be used) either 1/2 or 5/8" in diameter. The end is cut perpendicular. The tables usually show a rod cross diameter of 1.27 cm, which reflects their British/American origin. Rod gap measurements are typically considered accurate to $\pm 8\%$, when corrected for humidity, temperature, and density.

The rods may be 15 to 75 cm long and the gap will be from 2 to 200 cm. For impulse measurements, IEC and IEEE recommend horizontal mounting of the rod gap on insulators at 1.5 to 2 times the gap spacing above ground.

[Breakdown Voltage Tables](#)

Copyright 1998, Jim Lux / rodgap.htm / 8 March 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
CLICK HERE

<

SOLARIS**THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS****ENERGY21****DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND**

[Content on this page supplied with permission from this web site of Jim Lux](#)

Rod Gap Breakdown Voltage Tables

Table values valid for:

1.27 cm square rods

27 deg C

760 torr

15.5 torr water vapor pressure

11 g/cc water content for impulses.

Rod Gap		1/5 uSec	1/5 uSec	1/50 uSec	1/50 uSec
Spacing	Voltage	Pos impulse	Neg impulse	Pos impulse	Neg impulse
2	26				
4	47				
6	62				
8	72				
10	81	101	111	90	97
15	102				
20	124	179	208	160	178
25	147				
30	172	256	301	226	262
40	225	348	392	279	339
50	278	431	475	334	407
60	332	513	557	397	470
70	382				
80	435	657	701	511	585

90	488				
100	537	820	855	629	703

Humidity Correction

H2O Vapor Pressure (torr)	2.5	5	10	15	20	25	30
Correction Factor %	-16.5	-13.1	-6.5	-0.5	4.4	7.9	10.1

Rod Gap [procedures and construction](#)

Copyright 1998, Jim Lux / rodv.htm / 8 March 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



SOLARIS**THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS****ENERGY21****DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND**

[Content on this page supplied with permission from this web site of Jim Lux](#)

Spark Gap Correction Factors

Effects of atmospheric conditions

$$V = k * V_0$$

where k is a function of the air density d

$$d = p/760 * (293 / (273+T)) \text{ where } p \text{ in Torr and } T \text{ in degrees C}$$

d	0.70	0.75	0.80	0.85	0.90	0.95	1.0	1.05	1.10	1.15
k	0.72	0.77	0.82	0.86	0.91	0.95	1.0	1.05	1.09	1.12

The voltage increases with humidity varying some 2-3% over a normal atmospheric range of 8-15 g/m³.

Irradiation

If the gap is illuminated with UV or X-rays, it is more easily ionized. The effect is more pronounced with smaller gaps, a 20% reduction for short gaps of a few cm when irradiated. For this reason, UV irradiation is specified for accurate breakdown voltage tests, particularly with smaller gaps.



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)



[Content on this page supplied with permission from this web site of Jim Lux](#)

High Voltage Relays and other mechanical switches

High voltage relays are very similar in function to the common low voltage variety. The major difference is in the contacts, which must be designed for low corona losses (i.e. large radii of curvature), and for sufficient clearance distances to prevent flashovers, either between the contacts or between a contact and ground. The overall size can be reduced by operating the switch in an insulating gas or liquid with a higher breakdown than air. Switches designed to open with current flowing must make provision for quenching the arc that will be drawn, and are usually termed "circuit breakers".

The large separations required to isolate at tens or hundreds of kV require large actuating forces and distances. Electrical solenoids are used, often with some sort of lever system to increase the "throw", and with an insulating push rod to isolate the solenoid from the high voltage. Air actuated relays are also available, which has the advantage that the air hoses can be plastic, and hence the actuator itself can "float" at line potential.

Electric utilities use a variety of switches at high voltage. For lower voltages (< 50 kV) vacuum switches are popular. These have two contacts in a vacuum chamber with a bellows to allow one of the contacts to be moved, typically by some sort of solenoid arrangement. Ross Engineering, Jennings, and Joslyn are some of the well known manufacturers of these switches.

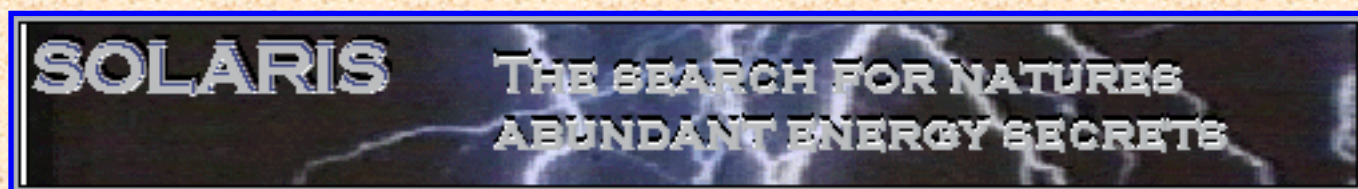
An older switch is the "oil switch" in which the contacts are immersed in an insulating oil, which helps quench any arc created when the switch is opened. The oil breaks down to form hydrogen gas which then rushes through the small gap where the arc is, "blowing" it out and cooling it.

There is a distinction to be made between "circuit breakers" and "disconnecting switches". A circuit breaker is designed to interrupt the fault current, which may be many kiloAmperes (a rating often stated as KAIC, KiloAmpere Interrupting Current). A disconnecting switch may carry a very large current, but not be designed to disconnect under that kind of load. In the former case, the circuit breaker is designed to either prevent an arc from forming, or to quench the arc after it forms.

A good review of circuit breaker technology may be found in *Scientific American*, Jan 1970(?).

Impact switches are mostly mechanical devices used to discharge capacitor banks into a load in a short time, e.g. in a magnetizer or spot welder. They are characterized by rapid closing speed and fairly high contact forces, to reduce the "on" resistance. As used in a capacitor discharge circuit, they don't have to interrupt any current when opened, or reset. A typical switch would use a large spring to close with some sort of mechanical "catch" to hold it open. The catch is released by a solenoid (or pulling on a rope), letting the contacts fly together. The contacts are often of some refractory metal to increase their life, although mechanical strength is probably a bigger design concern. A small arc forms between the electrodes as they approach, but it is of short duration, given the usual high closing speed. [Früangel](#) provides a fairly complete analysis which is summarized [here](#).

Copyright 1997, Jim Lux / hvrelay.htm / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)





SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS



ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Triggered Spark Gaps

Triggered spark gaps are very popular as fast high current switches. With proper design, a triggered spark gap can switch megawatts of power in a few microseconds, with jitters of less than a nanosecond. These devices make use of the very low impedance of an arc once the arc is established. Two electrodes are separated by sufficient distance that the gap doesn't spontaneously break down. The breakdown is initiated by a variety of means: UV irradiation from another spark or a laser, an overvoltage pulse, or reducing the gas pressure in the gap.

There is a lot of similarity to a xenon flash tube here. In a triggered spark gap, the idea is to switch a lot of current at high voltage, so the arc characteristics are optimized for that. In a flash tube, the idea is to generate light, so the design is optimized for that (i.e. use xenon (high lumens/watt), a long path (limit watts/volume), etc).

Some triggered gaps operate in a vacuum, for instance those sold by EG&G. Others use a gas filling which breaks down, as in those sold by Maxwell Labs. Both sealed and unsealed gaps are made.

Triggered spark gaps should be distinguished from other arc conduction devices in that they are bidirectional. Other devices like thyratrons and ignitrons have a preferred direction of current flow.

Here are some trigger mechanisms

Field distortion - The voltage on an auxiliary electrode (typically between the main gap electrodes) causes a local increase in the E field strength above the breakdown field. This technique is often combined with the swinging cascade design.

Swinging Cascade -

Irradiation - A spark across an auxiliary spark gap near (or within) the main gap produces UV light which ionizes the air in the gap or causes the emission of photoelectrons from the main gap electrodes, either of which reduces the breakdown voltage below the impressed voltage. Laser

triggered spark gaps use a pulsed laser instead of the auxiliary spark gap. The "Trigatron" developed by Meek, et. al., is an implementation of this technique.

Overvoltage - The voltage across the gap is momentarily raised above the breakdown voltage. This method is used in triggering high power xenon flash lamps by the "series" technique.

Suppliers:

- [EG&G](#)
- [Maxwell Labs](#)

Copyright 1997, Jim Lux/ hvtrigsg.htm / [Back to High Voltage Main Page](#) / [Back to home page](#) / [Mail to Jim](#) (jimlux@earthlink.net)



SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS

ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Rotary Spark Gaps

Many high voltage systems have a need for a repetitive switching action at fairly slow rates, i.e. less than 1000 per second. Examples of such systems would be radars (applying power to the magnetron) or tesla coils (impulse exciting the tuned circuit primary). The rotary spark gap is a mechanical means of repetitively shortening and lengthening a spark gap for switching purposes.

Why use a rotary gap?

Sparks are a fairly low loss conductor, particular when short and when carrying high current. Rotary spark gaps are typically constructed so that the gap distance at closest approach is overvoltaged by a factor of 3 to 10. Spark gaps also have the advantage that their "turn on" time is very short, substantially less than a microsecond. Rotary spark gaps are relatively inexpensive and require very little support system electronics, unlike hydrogen thyratrons (which require heater and reservoir power, as well as triggering electronics). Rotary spark gaps do have some jitter in their timing, not only from mechanical sources, but also due to the probabilistic nature of the spark initiation.

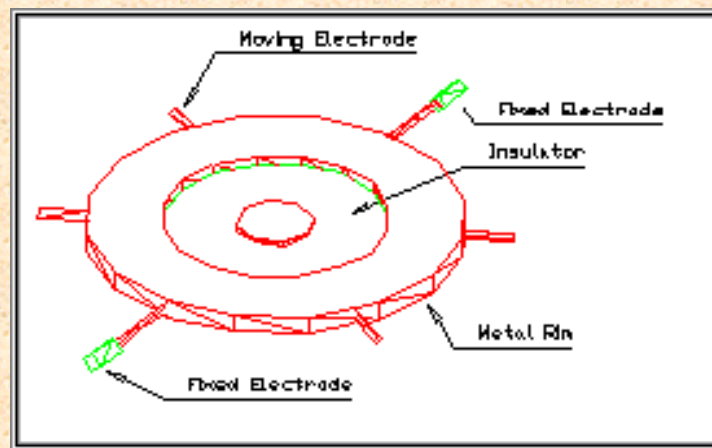
The rotary spark gap is best suited to a capacitor discharge or resonant charging type system, because spark gaps are really a "make" switch, and not very good at "breaking" a connection with significant current, because of the arc being drawn. If the load is such that the current oscillates, and the speed of the switch is chosen so that the current goes through a minimum as the gap separates.

Rotary spark gaps are usually operated in air, although sealed rotary gaps have been built for aircraft radar applications, where the change in air pressure would result in large fluctuations in the breakdown voltage of the gaps.

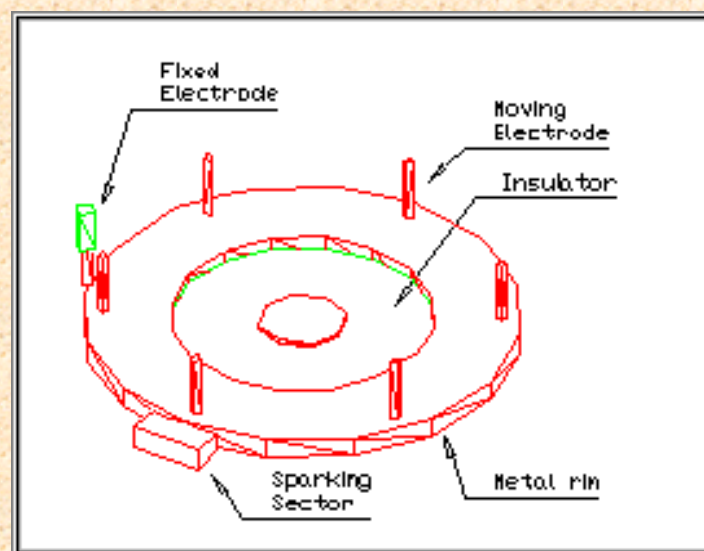
Mechanical configurations

There are a number of mechanical configurations possible for a rotary spark gap. The schematic diagram symbol often used for a rotary gap implies one of the configurations, shown in the following figure. As it happens, this is a poor design for most applications, because as the electrodes inevitably erode, the gap configuration changes, changing the timing characteristics of the gap. Axial endplay in

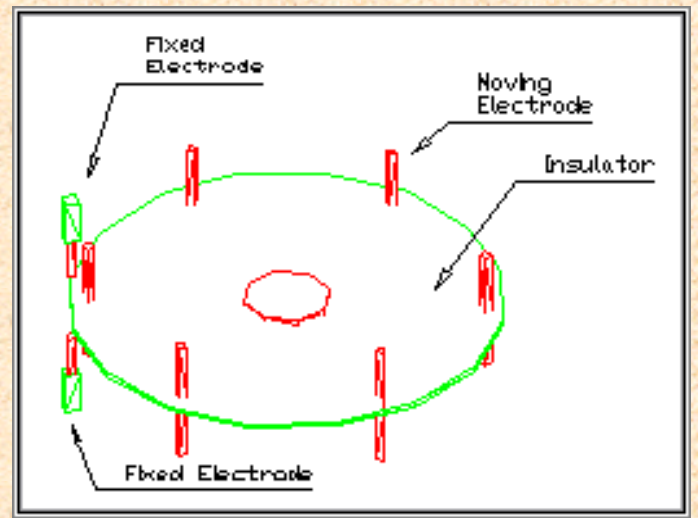
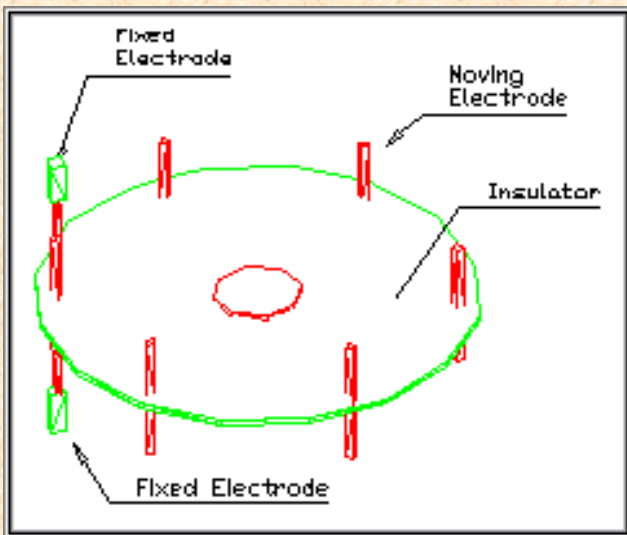
the motor or support bearings also changes the gaps. A gap of this type has been used at very high powers, at 10 megawatts and 1000 Amps, for example, where the gap was set somewhat greater than 0.05 inches. In that application, the electrodes were estimated to need replacement every 1000 hours.



A better approach, in general, is to have the electrodes move past each other, being parallel and overlapping some distance. There are several approaches to doing this. One, illustrated below, is to have a conductive rim for the rotor and connect to it from a "sparking sector" which is an electrode spaced a small distance from the rim. Brushes could also be used, but erode very rapidly in this sort of application. The sparking sector works well, and with a sufficiently large size spaced very close, the losses are negligible. A rotary gap of this type was used extensively for pulse powers of 500 to 3000 kW. The gap between the sparking sector and the rotor rim was set in the range 0.010 to 0.050 inches. The capacitance between the sparking sector and the rim is fairly large, compared to that between the pin electrodes, so most of the voltage appears across the pin gap.



Another approach is to have pairs of fixed electrodes, either arranged so that the moving electrodes pass by the fixed ones, as in the above scheme, or so the electrode ends approach. This latter approach has the same disadvantages as the scheme where the moving electrodes are radial. An advantage of the parallel pin gap is that the motor/bearing axial play doesn't affect the gap distance.



This latter approach is also convenient for systems where multiple circuits must be switched simultaneously, as in a Marx generator configuration. In such an application, the mechanical tolerances are substantially tighter, as the pins must be aligned with more than one set of fixed electrodes.

Rotary gaps have also been built using a perforated insulating disk which spins between two fixed electrodes. It is easy to control the interelectrode gap in this sort of system, but erosion of the insulating disk is a real problem. Also, for lower voltages, the disk must be quite thin so that the gap being interrupted is short enough to reliably break down.

Electrode wear

There is some experimental data for rotary spark gaps as used in radar sets from Bell Labs and the MIT Radiation Laboratory. The cathode wear for a gap operating in air at pulse currents of 40 to 170 Amps has been measured at 2-6 mg/amp hour, with the median value being 3-4 mg/amp hour. In a Nitrogen atmosphere, with no oxygen, the wear rate was 10-20 times greater. The anode wear was 1/5 that of the cathode.

Analysis of timing and jitter

Figure xxx shows the two electrodes as they approach and recede. This figure and the following equation assume that the moving electrode is moving along a straight line. The distance between the electrodes is:

$$\text{Distance} = \text{SQRT}(\text{DistancefromClosestApproach}^2 + (\text{DiamElectrode} + \text{MinSpacing})^2) - \text{DiamElectrode}$$

$$s = \omega * r * (t_0 - t)$$

(assuming $\sin(\theta) = \theta$)

The E field strength between the electrodes is then:

$$E = V / \text{Distance}$$

The time jitter of the gap can be held to less than 10 microseconds with proper gap design.

The impact of thoriated electrodes

If some degree of ionization in a spark gap before breakdown can be assured, then you don't have to depend on electrons emitted from the electrode surface to start the breakdown. The tungsten rod electrodes used in industrial arc welding are typically alloyed with a small amount of Thorium which is radioactive. The TBD particles emitted by Thorium will make the ionization of the gap before discharge more consistent. This will tend to reduce the jitter.

Mechanical stresses in the rotor

The mechanical design of a rotary spark gap should address the sizable stored energy and damage potential in a system with a rotor of significant mass spinning at relatively high speeds. Particular attention should be paid to the method by which the electrodes are attached to the rotor. The "centrifugal" force on these pins is:

$$\text{Force} = \text{mass} * \omega^2 * \text{radius}$$

For a 10 cm radius (8 inch diameter) disk, spinning at 3600 rpm ($\omega = 377$ radians/sec), the acceleration is 1450 G. A tungsten pin 2.5 mm (0.1 inches) in diameter and 5 cm (1 inches) long weighs about 5 grams. The force on the pin is about 70 Newtons (15.6 lbs). If the disk is made of 1.6 mm (.0625 inch) thick G-10 glass/epoxy, the load on the board is about 2500 psi, well within the allowable design stress for G-10 (around 15,000-20,000 psi). However, if the pins were to be made 1 inch in diameter, they would now weigh about 500 grams, and exert a force of 1600 pounds. The bearing surface is increased to .0625 square inches, making the load some 25,000 psi.

The gap should be surrounded by a "scatter shield" of some material that can contain the parts of the rotor should it come apart during operation. Polycarbonate (Lexan) makes a suitable shield, as would aluminum, steel, or fiberglass. Opaque materials also have the advantage of suppressing the significant UV light emitted by the sparks, although, in some applications, the visual appearance of the gap may be desired (e.g. display Tesla coils).

Some rotary gap design data

The following table is taken from [Früangel](#), who in turn took it from [Lebacqz](#).

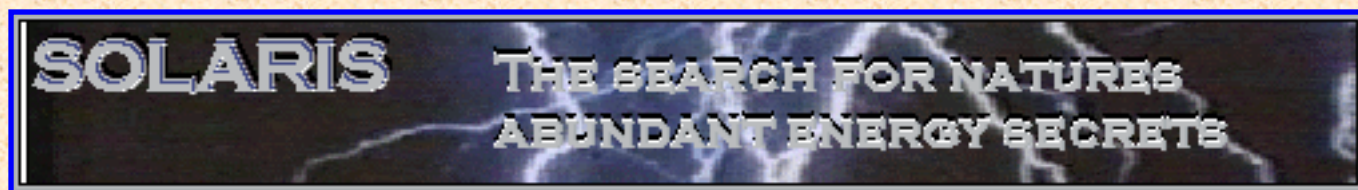
<u>Electrical Characteristic</u>	<u>Resonant Charging</u>				<u>DC Charging</u>	
Voltage Range (kV)						
Peak current (A)						
Normal operating voltage (kV)	7-16	5->9	12-22	12-22	5->9	8-13
Normal operating current (A)	160	>90	220	220	>90	130
Normal average current (mA)	12	8	~18	~18	8	13
Pulse recurrence frequency (pps)	120	80	180	180	80	130
Pulse duration (µSec)	45	100	130	130	70	70
Pulse power (kW)	410	825	800	800	750,375	580
# of fixed pins	0.9	1.5	0.9	0.9	1.125,2.25	0.9
# of rotary pins	600	360	1500	1500	300	700
Diam of pins (inch)	1	1	2	2	2,1	1
Motor speed (rpm)	7	14	10	14	4	10
	0.100	0.188	0.125	0.150	0.125	0.120
	3500	3535	4800	3400	5600	3450

References

[Früangel](#), pp 140-149

Glasoe & [Lebacqz](#), *Pulse Generators*, pp 276-282, pp286-292

Copyright 1997, Jim Lux / 18 Oct 1997 / rotgap.htm / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)





SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS



ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

Pulse Power Switching Devices - An Overview

By John Pasley

5/8/96 (html'ized by Jim Lux, 25 Aug 1997)

Copyright John Pasley 1996. This document may be freely distributed via. any means in part or in whole, however the authors name must be included and correctly attributed. The References Listed and The Disclaimer must also be included.

Foreword by Carey Sublette:

An essential component of modern nuclear weapon technology is the ability to rapidly switch high voltage/high current electrical circuits at very high speeds.

The detonators that fire high explosive implosion systems (exploding wire or exploding foil detonators) require voltages in the range of (roughly) 2-20 kilovolts, a complete detonating system may draw currents ranging from 10 to 100 kiloamps. Pulse neutron tubes, used to precisely control the initiation of fission chain reactions, require voltages of 100 to 200 kilovolts, and currents in the ampere range. These currents must be turned on rapidly and precisely, timing accuracies of tens to hundreds of nanoseconds are required.

Switching devices that meet these stringent requirements often require specialized technologies or skills to manufacture. They are also dual use - in addition to weapons applications they have many civilian uses too. Examples include controlling flash lamps used in high speed photography or industrial photochemistry, generating high power radar pulses, in high energy physics laboratory equipment, to name but a few. Consequently commercial sale and international trade in these devices is permitted, but it is also regulated. Attempts to circumvent these regulations have gained considerable public attention in a number of technology smuggling cases in the 1980s and 90s involving one particular type of device - the Krytron. These devices have even appeared prominently in popular entertainment as the "McGuffin" used to drive espionage thrillers - like Roman Polanski's

"Frantic".

This article summarizes the basic technologies and devices, and their principle properties.

Section 1.0: Introduction.

Before entering into a consideration of the individual devices that concern us, it would be as well to explain some of the associated technology/terminology.

1.1 Switching basics and terminology.

The switch is possibly the most elementary device in the field of electronics. A switch controls the flow of current in a circuit in a manner such that either the current flows at a value determined by the other components in series with it, or does not flow at all, as the case may be. However this ideal behavior is actually never exactly what is seen in real life. A switch has its own parameters that determine how fast it can switch from open to closed, or how rapidly it can interrupt the flow of current once it has been opened. Also of course there are more elementary considerations such as the current handling capacity of the switch and the peak voltage it can cope with before damage or other unwanted effects occur.

Mechanical switches such as are common in the home are in actuality far from ideal in their behavior. The time taken to switch from off to on (the commutation time) is typically in the millisecond range. Also spurious effects such as bouncing may occur as the switch fluctuates rapidly from open to closed in the process of being physically manipulated by the operator.

Electromagnetic relays and reed switches experience similar problems to those seen in the humble light switch. Long commutation and switch bounce are standard features of virtually all mechanical switching devices.

With the advent of transistors and similar devices such as thyristors one would have thought that these slow switching problems would be things of the past. This is in fact largely true. But semiconductors are limited in other ways, it is very hard to find semiconductors capable of switching many kiloamperes especially at potentials in the kilovolt region, and those devices that can manage high currents such as the larger thyristors are troubled by overly high commutation times. Whilst there are now semiconductors coming onto the market capable of performing at these extremes of current and voltage there are some requirements which put even these devices to shame. If you want to switch 50 kilo Amperes with a sub 20 nanosecond commutation time at 20kV you are going to be in trouble if you are relying on semiconductor technology. However there is an alternative class of devices that have been around long before the humble transistor came on the scene. You might think that vacuum tubes and similar are a thing of the past. But for problems of this magnitude they are the only things on the market that will do the job.

1.2 Vacuum and Gas filled switching tubes, introduction and terminology.

There are a great many different types of vacuum tube in existence, however it is possible to group tubes according to some fairly basic criteria. There are two primary distinguishing features, the source of free electrons within the device and the gaseous filling (or lack of it) within the tube envelope. The later of these two concepts we have already introduced by implication. A vacuum tube is a device with a vacuum (very low pressure gas) filling. And a gas filled device is, as the name would suggest, filled with gas that might be at a pressure somewhat above or below atmospheric. The type of gas used is also an important feature, particularly in switching tubes where a wide variety of fillings are encountered.

The source of the free conduction electrons in the device may be either thermal such as a heated filament physically associated with the cathode of the device - a hot cathode, or alternatively a simple consequence of a high voltage gradient across the device, resulting in autoemission from the cathode. A device employing this latter method is known as a cold cathode device. In high voltage switching the presence of high voltages, and hence the possibility of large voltage gradients within devices means that the cold cathode system, quite a rarity in most other types of tubes, is the norm rather than the exception.

Other important terms encountered in gaseous state switching tubes:

Delay Time

The delay time is the time taken between the application of a trigger pulse and the commencement of conduction between the primary electrodes.

Jitter

Jitter is the variation of time delay from shot to shot given similar electrical stimulus

Commutation time.

The commutation time is the time taken for the conduction to reach maximum once it has commenced. (i.e. From the time from the end of the delay time to the time at which the maximum level of conduction occurs.)

It should be pointed out that none of the switching tubes we are about to consider look very much like the things in the back of an old radio set. Many are large, some exceptionally so. Also glass has largely given way to ceramic in the higher powered devices. Before you go down your local electronics shop or radio shack it should also be pointed out that many of these devices besides costing \$100's (often \$1000's) a piece, and are also largely unavailable to the general public due to their application in advanced missile and nuclear weapon technologies. Of these devices the most 'everyday' is the ignitron which finds much application in industrial welding situations.

The following devices are considered herein:

2.0 Vacuum and Gaseous State Switching devices

- 2.1 Introduction to Cold Cathode Trigger Tubes
- 2.2 The Krytron.
- 2.3 The Sprytron.
- 2.4 The Thyatron.
- 2.5 The Over Voltage Spark Gap.
- 2.6 The Triggered Spark Gap.
- 2.7 The Ignitron

In addition I will include a short section on some of the solid state devices that are finally beginning to fill the shoes of the above gaseous state device (to a very marginal extent in most cases).

Section four will detail the ways in which these devices might be employed in nuclear weapons.

2.0 Vacuum and gaseous state switching devices

Most of the devices in this section switch by inducing an arcing process in a gaseous medium. I have included in the triggered spark gap section some mention of devices that actually use a liquid or solid substitute for the gaseous material that is the norm in triggered spark gaps.

The process of arc formation is actually quite complex physically, and it will not be gone into in any depth. Anyone who wishes to look more deeply into this aspect of device operation may contact the author for some suggestions as to suitable text books for use in such study.

2.1 An Introduction to Cold Cathode Switching Tubes.

Cold cathode trigger tubes are physically small devices designed to switch impulse currents and voltages of relatively small amplitude. Usually they are intended, as their name suggests, to trigger other larger devices.

Typically cold cathode trigger tubes are designed to switch pulses of a few hundred volts and a few hundred milliamperes. Most trigger tubes have three or four electrodes, anode, cathode (+ve and -ve terminals respectively), a trigger/control electrode and sometimes a priming electrode.

A trigger tube performs in a very simple manner akin to that of a triggered spark gap, excepting that usually the conduction is not by an arcing but glow discharge. The glow discharge is initiated when all of the following factors are present:

- i) A sufficiently high voltage is present across the device (between anode and cathode)
- ii) A trigger pulse of sufficient amplitude is present at the trigger electrode.
- iii) The gas in the tube is primed.

Cold cathode trigger tubes rely upon some external or internal source to ionize the gas suitably for conduction to commence (This is called priming). This means that in theory some of these tubes will only switch a minute or so after the application of a suitable triggering voltage to the appropriate terminal of the device when some natural source of ionizing radiation ionizes the gas (forming a

plasma) and hence causes conduction to commence. The triggering is basically random- it is subject to huge statistical variation even in apparently similar environments. Some devices incorporate a suitably ionizing source to reduce the maximum possible time delay after trigger application considerably. This source may be an electronic, radioactive or photon source of some form or other. However even the standard commercial devices often display a large variation (up to and above an order of magnitude different) between devices fired in sunlight and darkness, a standard commercial tube Z900T for instance displays a 20 μ s delay in day light and a 250 μ s delay in darkness.

2.2 The Krytron:

Krytrons are completely different to the familiar Klystrons often encountered. Krytrons are a highly specialized variety of cold cathode trigger tube. They were one of the first products developed by the US based company EG&G. The Krytron has 4 electrodes, and is filled with a gas at low pressure. A Krytron is distinguished among cold cathode trigger tubes for a variety of reasons.

The Krytron is designed to switch moderately high impulse currents (up to around 3kA) and voltages (Up to around 5kV) in an arc discharge mode, compare this with the usual glow discharge of the standard trigger tube. Also, and perhaps more importantly, the Krytron is able to turn on this arc discharge very rapidly, the reason being that it relies on an already present plasma to support the conduction, rather than waiting for the plasma to be formed as a result of priming etc. This plasma is created and sustained by a keep-alive current between the keep-alive electrode and the cathode of the device. When the trigger is applied under the conditions of a high anode to cathode voltage, this plasma forms an easy path for the main conduction between anode and cathode.

The fact that a conduction path is already established prior to triggering makes a huge difference in the commutation time of these devices compared to standard cold cathode trigger tubes. Commutation times below 1 nanosecond are achievable with Krytrons and the time lag between application of trigger and the commencement of switching may be less than 30 ns with an optimized driver circuit. (Note this delay is largely due to the fact that the ionized path will need to spread from the keep alive terminal to the anode of the device).

Compare this delay time to that seen in the standard trigger tube which is dependent upon many environmental factors and typically 3 or 4 orders of magnitude greater. Note that the variation in time delay exhibited by the krytron is almost totally independent of environment, however the time delay may be reduced up to a point with increasing trigger voltage. Likewise the commutation time is generally decreased if the rise time of the trigger pulse is also decreased. Given identical trigger pulses however a krytron will have a very similar time delay from one shot to the next. This variation is known as jitter and may be less than 5ns in optimal circumstances.

This short commutation time and inherent environmental insensitivity of the krytron is achieved by including a radioactive priming source, the weak beta emitter Nickel-63. The source maintains weak the gas filling the tube in a weak state of ionization, which aides the formation of the initial glow discharge between the keep alive and the cathode. Ni-63 has a half-life of 92 years and produces beta particles with an energy of only 65.9 KeV and no gamma radiation at all. The quantity in each device is less than 5 microcuries and presents no significant hazard. Usually the source is pulse welded to a

piece of Nickel wire that is in turn welded to one of the electrode supports.

Priming sources (which is also occasionally a radioactive source) are also be employed in standard trigger tubes to reduce their environmental sensitivity.

Krytrons typically come in a small glass envelope somewhat similar to a neon indicator bulb with more leads.

Krytrons require a high voltage pulse (500V to 2kV) to be applied to the trigger electrode to fire successfully. This pulse is almost always generated by a pulse transformer fired by a capacitor discharge in the primary (rather like a simple strobe tube firing circuit).

The krytron often has only a short life expectancy if used regularly (often as few as a couple of hundred shots) However when used within the appropriate parameters and well within the expected life time they are extremely reliable, requiring no warm up and being immune to many environmental factors to a large extent (e.g. vibration, temperature, acceleration).

These properties, combined with the small size make the krytron ideal for use in the detonating circuitry of certain types of missiles and smart bombs. The krytron may be used directly to fire a high precision exploding wire, or alternatively as part of the triggering circuitry for a triggered spark gap or similar ultra high current triggering device as used in exploding foil slapper type detonators and larger EBW circuits.

Krytrons are used in firing circuits for certain lasers and flash tubes and also in some pulse welding applications, often as triggering devices for other larger devices such as Thyratrons and spark gaps.

The export/sale of krytrons is controlled under Dual Use Guidelines.

2.3 The Sprytron.

The Sprytron, otherwise known as the Vacuum Krytron, is a device of very similar performance to the Krytron. Though it generally exhibits a somewhat lower time delay after triggering. The Sprytron is designed for use in environments where high levels of radiation are present. The sprytron is a hard vacuum 'filled' device unlike the krytron which, as noted above contains a low pressure gas.

The Sprytron has only three leads, (no keep alive), but is otherwise very similar in outward construction to the Krytron. The reason for the use of a vacuum filling is almost certainly that there is no medium present for radiation from the external environment to ionize (such ionization could promote spurious triggering effects.)

The Sprytron requires a more powerful trigger pulse than the Krytron, as the device works by forming an arc directly between the trigger and the cathode, which causes the tube to breakdown (go into conduction) by disrupting the field between the anode and cathode.

Although it is usually stated that Krytrons were the devices sought in smuggling involving Israel, Iraq

and Pakistan, it may well be that Sprytrons were involved with at least some of these cases, rather than the gas filled krytron, due to the very similar size and performance coupled with very high radiation resistance.

The reason that radiation sensitivity is important in nuclear warheads is not actually that the radiation levels inside a bomb are liable to be especially high. It is rather that a nearby nuclear explosion may in the case of a non radiation hard device, cause an undesirable condition in the warhead. This defect may prevent the weapon from being able to explode either at the correct target or at all. Also it is conceivable that such a scenario could result in the detonation of the second device. (nuclear dominos if you like). It is not considered particularly helpful to have nuclear weapons explode at the wrong moment. Even a few tenths of a second can be vital if the target is such that it requires a very precisely timed detonation. (e.g. if an attempt is being made to damage a hardened installation such as a missile silo or command center)

A Sprytron is triggered in a similar fashion to Krytron, but as mentioned requires a higher energy trigger pulse and therefore a more powerful trigger transformer etc. EG&G makes trigger transformers optimized for use with their various tubes, and also make devices named Krytron-Pacs which incorporate a gas filled krytron and trigger transformer in a single housing.

One final point. It is interesting to note that in application circuits (references 1 and 4) the sprytron is always shown directly switching a load (an Exploding bridge Wire.) and a Krytron is always shown triggering a secondary device such as a triggered spark gap. This may just be coincidence, but as there is no apparent reason why a sprytron couldn't be used in either role, it also occurs to me that possibly such a design might be significant in the design of nuclear warheads, certainly this would appear to be a useful combination (see section 4).

2.4 Thyratrons:

Thyratrons come in several varieties. All work similarly to the semiconductor Thyristor, one difference being that in many designs (Hydrogen Thyratrons are a common exception) the gate must be biased highly negative in the off state and then biased positive to achieve switching. Like Thyristors, Thyratrons operate like a latching switch, ie. once you have turned them on you can only turn off by cutting the supply to the main circuit. Mercury filled Thyratrons are the slowest, least useful type and are much more restricted environmentally than other types due chiefly to problems with the mercury condensing . They are rarely used as they have few advantages of the thyristor. Hydrogen Thyratrons are *much* faster switching than Thyristors. Some can achieve commutation in under 20ns. Inert gas fillings tend to offer superior performance compared to mercury filled devices, without matching the speed of the Hydrogen filled devices. Note that Hydrogen Filled Devices employ a hot cathode.

The actual Physical construction/ operation of the thyatron is quite complicated compared to the other devices we have looked at and no attempt will be made to explain it's operation. The reader is advised to consult a wide range of books as devices employing different fillings, or electrode heating methods operate differently. It is not considered to be especially important to consider all these variations here as this is merely an overview of these devices and is not intended to be the final word

on the subject. However, in order to differentiate the thyatron from other similar devices and to define it in at least some physical manner here follows Frungel's (Ref.4) definition of the device:

'By the term 'thyatron' there is meant a discharge chamber in which are arranged a cathode, one or several grids, and an anode, and which is filled with an inert gas or metal vapor.'

Some Thyratrons can handle up to 50kV(double gap types) switch thousands of Amperes and handle very high power outputs(e.g. CX 1154 can handle peak powers of 40MW). Typical applications are Radar pulse modulators, Particle accelerators, Lasers and high voltage medical equipment. Another variety of thyatron is filled with Deuterium. These Deuterium filled devices are similar to their Hydrogen filled counterparts but the sparking potential for Deuterium is higher thus allowing even higher voltages to be handled. E.g. E3213 can switch 70kV (double gap type). Specialist Thyratrons with ceramic and metal bodies are encountered. These are designed to be used in extreme environmental conditions. There is a wide variety of grid configurations seen in Thyratrons, it would be impractical to consider them all here. Manufacturers of Thyratrons Include EG&G, GEC, English Electric Valve Co.Ltd, M-O Valve co.Ltd. Big Thyratrons often require you to get a big box full of driver/control circuitry. Prices vary from a couple of dollars to thousands. Hot and cold cathode type devices are encountered.

Note these ratings are the exception rather than the rule in Thyatron devices, devices designed for sub kilovolt voltages and only capable of handling a few tens of amps pulsed are common enough.

Thyratrons typically come in either small multi pin base type packages such as are common in other vacuum tubes or in the case of the higher current devices large tubular packages with hefty end connectors.

2.5 The Over Voltage Spark Gap

The Over voltage spark gap is essentially just two electrodes with a gap between. When the voltage between the two electrodes exceeds the breakdown voltage of the gas, the device arcs over and a current is very rapidly established. The voltage at which arcing occurs in these devices is given by the Dynamic Breakdown Voltage, which is the voltage at which the device will breakdown for a fast rising impulse voltage. Note that this voltage may be as much as 1.5 times greater than the static breakdown voltage (breakdown voltage for a slowly rising voltage.) how much greater than the static breakdown voltage the actual breakdown voltage is will be depends almost entirely on how rapidly the voltage rise, a shorter rise time means a higher breakdown voltage. Commutation times for these devices are exceptionally low (sometimes less than 1nanosecond).

Overvoltage gaps are primarily used for protection. But in combination with the other devices mentioned here they are commonly used to sharpen the output pulses (decrease the rise times) of very high current pulses from triggered switching devices e.g. Thyratrons.

The size of these devices is almost entirely dependent upon how much current/voltage they are intended to switch, There is really no limit as to the size of these devices they can be as small as

krytrons, however they can also be very big, and devices intended to switch MA will be just that.

2.6 Triggered spark gaps

The triggered spark gap is a simple device, a high voltage trigger pulse applied to a trigger electrode initiates an arc between anode and cathode. This trigger pulse may be utilized within the device in a variety of ways to initiate the main discharge. Different spark gaps are so designed to employ one particular method to create the main anode to cathode discharge. The different methods areas follows-

Triggered spark gap electrode configurations:

- i) Field distortion: three electrodes; employs the point discharge (actually sharp edge) effect in the creation a conducting path
- ii) Irradiated: three electrodes; spark source creates an illuminating plasma that excites electrons between the anode and cathode.
- iii) Swinging cascade: three electrodes; trigger electrode nearer to one of the main electrodes than the other.
- iv) Mid plane: three electrodes; basic triggered spark gap with trigger electrode centrally positioned.
- v) Trigratron: trigger to one electrode current forms plasma that spreads to encompass a path between anode and cathode.

The triggered Spark gap may be filled with a wide variety of materials, the most common are-

- 1) Air
- 2) SF₆
- 3) Argon
- 4) Oxygen

Often a mixture of the above materials is employed. However a few spark gaps actually employ liquid or even solid media fillings. Solid filled devices are often designed for single shot use (they are only used once- then they are destroyed) Some solid filled devices are designed to switch powers of 10TW (10 000 000 000 000 Watts) such as are encountered in extremely powerful capacitor bank discharges. Except (obviously) in the case of solid filled devices, the media is usually pumped through the spark gap. Some smaller gaps do not use this system though.

Usually Gas filled spark gap operate in the 20-100kV / 20 to 100kA range though much higher power devices are available. I have one spec for a Maxwell gas filled device that can handle 3 MA - that's 3 Million Amperes! But then it is the size of a small car!! More commonly gas filled devices have dimensions of a few inches. Packages are often shaped like large ice pucks though biconical, tubular and box like structures are also seen.

Sparkgaps are often designed for use in a certain external environment(eg. they might be immersed in oil). A system for transmitting the media to the appropriate part of the device may sometimes be included. Common environments used are:

- a)Air
- b)SF₆
- c)Oil

Typical spark gap device no.'s are: TG7, TG113, TG 114 etc. etc.

Spark gaps are damaged by repeated heavy discharge. This is an inevitable consequence of such high discharge currents. Electrode pitting being the most common form of damage. Between 1 and 10 thousand shots per device is usually about what is permissible before damage begins to severely degrade performance.

EG&G make miniature triggered spark gaps specially designed for defense applications. these devices are physically much smaller than normal spark gaps (few cm typical dimensions) and designed for use with exploding foil slapper type detonators.

Laser switching of spark gaps. The fastest way to switch a triggered spark gap is with an intense pulse of Laser light which creates a plasma between the electrodes with extreme rapidity. There have been quite a few designs employing this method, chiefly in the plasma research area.

Triggered spark gaps tend to have long delay times than Thyratrons (their chief competitor, at least at lower energies) However once conduction has started it reaches a peak value exceptionally rapidly (couple of nanoseconds commutation.)

2.7 Ignitrons

The ignitron is mercury vapor rectifier in which an arc is switched between a (usually graphite) anode and a mercury pool cathode. The discharge is initiated by an ignitor electrode which dips into the mercury pool cathode. On application of a suitable impulse current/voltage to this ignitor an electron emitting source is formed at the point at which the ignitor contacts the pool. This initiates the arcing between the anode and cathode.

It is important that the ignitor should be triggered correctly. The ignitor requires a certain energy for successful ignition and also an 'ignitor characteristic' application of this energy in terms of current and voltage with respect to time. Misfiring or ignitor damage will otherwise occur. It is also vital that no significant negative voltage should appear at the ignitor with respect to the cathode else ignitor destruction will be the inevitable result.

There are two main ways by which the trigger can be biased:

Anode excitation: common in resistance welding applications here the anode bias is connected to the ignitor by means of a switch (thyristor, thyatron etc.) and a resistor/fuse network. The ignitor current drops rapidly on ignition as the anode-cathode voltage drops very low during conduction.

Separate excitation: as the name suggests, here the ignitor circuit is largely independent of the main circuit.

Ignitrons are often used in parallel for AC power control applications.

Ignitrons must often be cooled when used continuously (ie. Not single shot as in capacitor discharge) Water cooling is commonly employed. It is vital that Ignitrons must be used in the correct temperature range to hot or to cold can be very bad news for these devices- (cold leads to mercury vapor condensing on the anode.)

Ignitrons are very limited with regards their physical orientation. This reason being simple that they rely upon a pool of liquid at one end of the device that must be correctly positioned for the ignitor to function correctly. Positioning the device so that it leans over at an angle of more than 2 or 3 degrees from the vertical is fatal.

Most ignitrons operate at most currents between 5 Amps and 100kA and may be suitable for voltages from a couple of hundred to 20 000 Volts.

Thyratrons and Krytrons are sometimes used in ignitron triggering circuits along with the familiar thyristor.

Ignitrons are suited to applications where power control of high voltages or currents is required. Welding is probably the most common application.

3.0 Solid State Devices.

(Note this section may well be considerably expanded following further research by the author.)

There are now a few commercially available transistors on the Market which can switch many tens of kV. There are also a few transistors about that can handle pulsed currents above 5kA. These devices may match for example Krytrons and Sprytrons in terms of electrical performance, but not in terms of size and (in the case of the Sprytron) radiation hardness.

Thyristors are widely available in designs that can handle upwards of 10kA pulsed at several kV. They are however very slow switching devices and are not capable of achieving even low microsecond switching speeds.

A new class of devices is at present showing great promise in the R&D sector. These devices are optically (usually LASER) switched devices employing GaAs or Diamond film technologies. The reader is advised to consult the appropriate reference below for more information relating to these devices.

4.0 Pulse Power Switching Applied to Nuclear Weapons Design

(This section is as yet unavailable) Check the high energy weapons archive for a more current version

Final note to the reader:

Some of the devices I have mentioned are subject to strict control due to their military applications. None of the above information is however in any way restricted or controlled. For clarity switching devices that are restricted by dual use guidelines are as follows: (courtesy Oak Ridge National Laboratory)

(a) Cold-cathode tubes (including gas krytron tubes and vacuum sprytron tubes), whether gas filled or not, operating similarly to a spark gap, containing three or more electrodes, and having all of the following characteristics:

1. Anode peak voltage rating of 2500 V or more,
2. Anode peak current rating of 100 A or more,
3. Anode delay time of 10 microsecond or less,

and

(b) Triggered spark-gaps having an anode delay time of 15 microsecond or less rated for a peak current of 500 A or more;

(c) Modules or assemblies with a fast switching function having all of the following characteristics:

1. Anode peak voltage rating greater than 2000 V;
2. anode peak current rating of 500 A or more; and
3. turn-on time of 1 microsecond or less.

Acknowledgments:

I would like to thank the following for their help in the compilation of this article:

Carey Sublette for providing a great deal of assistance and encouragement. Roy Schmaus for providing the original www site for the vacuum/gas device info. JPG electronics for providing components used in the testing of certain ideas.

References: (in alphabetical order by title)

1. EG&G Catalogues/ Material. (RE: Components)
2. Exploding Wires Vol. 4, Proc. of 4th Conf. on the Exploding Wire Phenomena. Ed. Chace and Moore -Plenum Press (RE: EBW's)
3. High Power Optically Activated Solid State Switches, ed. Rosen And Zutavern- Artech House (RE: Solid state devices)
4. High Speed Pulse Technology by Frank Frungel -Academic Press. (RE: EBW's, FCG's, components)
5. High Velocity Impact Phenomena by Ray Kinslow-Academic Press. (RE: Foil Slappers)
6. IEEE publications (please contact author for more details).

7. Maxwell Catalogues. (RE: spark gaps)
 8. Mullard Valves and Tubes Book 2 Part 3 (RE: components)
 9. Nuclear Weapons Frequently Asked Questions; Section 7 Nuclear Weapons Nations and Arsenals by Carey Sublette. (RE: smuggling info. relating to krytrons)
 10. The Times (RE: smuggling info. relating to krytrons)
-

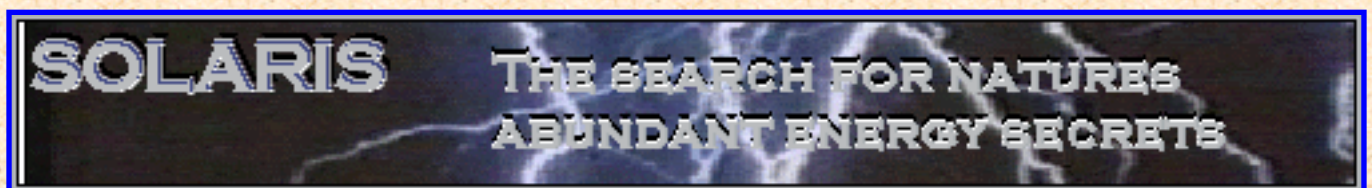
FURTHER INFORMATION PERTAINING TO THE SUBJECT MATTER WILL BE MUCH WELCOMED BY THE AUTHOR.

Information regarding the author: I am not an expert in any of the above technologies and I will welcome any corrections. However please could anyone providing information also provide references to either the material they present or as to themselves so that their contribution may be given due weight.

Anyone who would like to contact me (the author) for whatever reason should mail: kc76@cityscape.co.uk (NO LONGER VALID)

Disclaimer:

I the author assume no responsibility for anyone who injures/kills themselves trying to implement any of the above technologies. High voltages are generally exceptionally dangerous, and none of the above is intended or should be used to provide instruction in the correct procedures for building or constructing high voltage circuitry of any description. High voltage is used here to describe any voltage which may cause death i.e. anything above 50V.



The word "SOLARIS" in a stylized, metallic, blocky font.The text "THE SEARCH FOR NATURE'S ABUNDANT ENERGY SECRETS" in a metallic, blocky font, set against a background of lightning bolts.The text "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.The text "DISCOVERING NATURE'S POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font, set against a background of lightning bolts.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Transformer Measurements

You may want to determine the various parameters of a transformer without having any manufacturer's information available. In the early stages of experimentation, you may be working with equipment and components that have been "acquired" from other projects as surplus. Or, you may be at a surplus yard, and want to determine if that transformer you can pick up cheap is going to work for your needs. I own a lot of very heavy scrap now, having bought a number of transformers on spec, hoping they would work for my needs.

You'll need a variable voltage AC source (like a variac), a voltmeter, an ammeter, and for some measurements either a watt meter or an oscilloscope. A couple of big power resistors in low resistances (100 ohms, 100 W) will also be useful.

Often, the nameplate or markings on the transformer don't tell you everything you would like to know, particularly in the case of surplus.

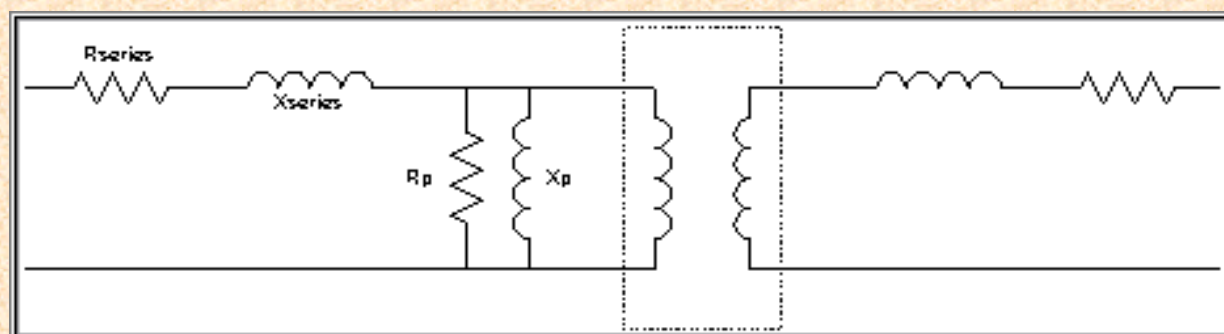
Per Unit system of ratings - commercial power distribution transformers have fairly complete data on their nameplates, but it is often stated in terms "per unit". Per Unit measurements are essentially percentages of the rated capacity. For instance, a power transformer might be rated at 10 kVA, and have a rated loss of .03 per unit. 10 kVA multiplied by the .03 gives a rated loss of 300 Watts. Impedances are also usually stated in per unit values

First, you need to identify the windings. An ohmmeter can help you determine which wires are connected to which windings, by looking for continuity. Sometimes, you can determine the order of taps by the resistances. However, the resistance is affected by the size of the wire, as well as the number of turns, so you can't use the ohmmeter to determine voltages or currents. In general, the heavy wires or terminals are for the low voltage windings. A notable exception is some power supply transformers that have some medium voltage windings to provide isolated bias supplies at low currents.

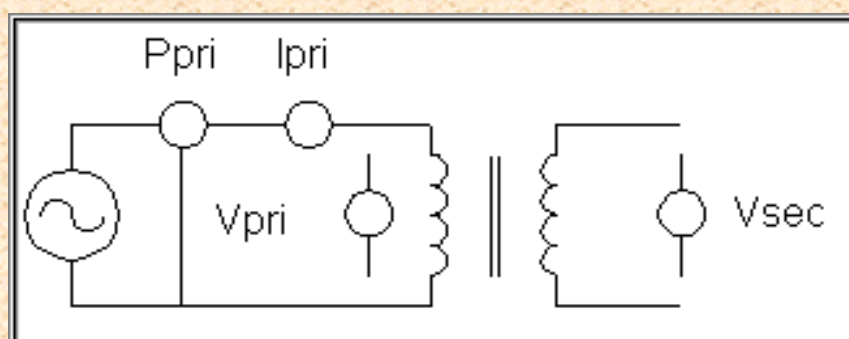
Almost all the parameters of the transformer can be determined by making a series of measurements with the secondary open circuited and then shorted. The choice of which winding is primary and

secondary is arbitrary for measurement purposes. For commercial distribution transformers, these measurements are often made at 115 Volts, as measurement equipment is readily available for that voltage. In the case of a transformer with a HV winding and a LV winding, the 115 Volts is applied to the HV winding for safety reasons. In the lab, lower voltages are convenient: using 1.15 Volts or 11.5 Volts allows simple scaling of the results.

Real transformer model



First, identify windings and approximate no load turns ratios. Apply a low voltage (say 10 volts) to what you think a high voltage winding might be. Measure the voltages on the other windings. You use the high voltage side here for safety: Say you had a 110V:15kV transformer with a 6.3V filament winding. If you applied 10 volts to the 6.3V winding, you'll get 20 kV+ out of the high voltage winding which might cause a few surprises. So, until you've identified all the windings, work with low voltages.



Hook up a voltmeter to the secondary. Apply power to the primary, measuring the current, voltage, and active power drawn. Note the power meter shown in the above diagram. If a true watt meter is not available, you can measure the active power consumption by putting a resistor in series, and making a set of RMS measurements. The details of this procedure are described [here](#).

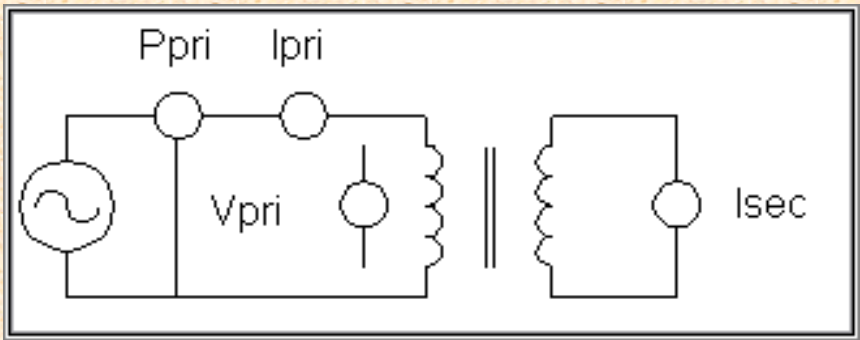
The turns ratio can be calculated by:

$$\text{Turns ratio} = E_{\text{sec}}/E_{\text{pri}}$$

which, of course, should be an integer. Be aware that the output voltage written on the spec sheet or the transformer itself may be at rated load, and somewhat less than the no load voltage. The active power drawn is due to the core losses, and will typically be a few percent of the rated capacity.

The magnetizing power is:

Now, disconnect the primary voltage. Short the secondary through an ammeter.



Starting with a low primary voltage, bring the primary voltage up until the current is a reasonable value, say half the rated primary current. Measure the secondary current (which should be the primary current divided by the turns ratio), the primary voltage, current, and active power.

Circular Mils

The area of conductors is often specified in Circular Mils, defined as the diameter in thousandths of an inch (mils) squared. This is different from the actual cross sectional area in square mils, which would be $\frac{\pi}{4} * \text{diam}^2$. That is, square mils = .7854 * circular mils.

Estimating the power handling

1) Look at the size of the wires. No right thinking transformer manufacturer is going to run hundreds of amps down 20 gauge wires, nor are they going to use 4/0 wire for a winding that will carry 30 mA. Very low current windings may use heavier wire than required to carry the current to make fabrication easier. However, copper costs money, as does a larger core to accommodate bigger windings, so particularly for mass production transformers, the wire is probably the smallest that will carry the current. Typical design guidelines are 700 circular mils/amp or 1000 cmil/amp. The following table relates common wire gauges to rated current.

Wire Gauge	Diameter		Area		Design Current	
	mils	mm	Circular Mils	mm ²	@ 700 cmil/A	@ 1000 cmil/A
10		0.254	100	0.0507	0.146	0.10

2) Look at the core cross section:

Here are some approximate transformer design equations that will get you into the right area:

- Core cross section area (sq inch) = $.16 * \sqrt{VA}$
- Turns/Volt = $5 / \text{Core cross section}$

This last equation is a special case of:

$$\text{Voltage} = 4 * F * f * a * B * N * 1E-8$$

where

F = Form factor, typically around 1.11

f = frequency in Hz

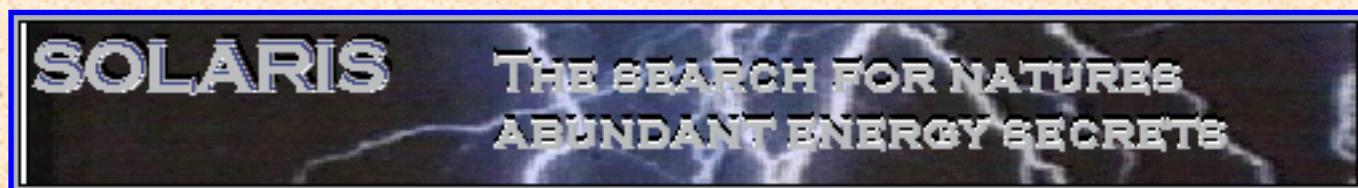
a = core cross sectional area in sq inch

B = flux per square inch (typ 75,000)

N = number of turns

Examples of measurements and calculations

[GE Type 5021G10 transformer](#)



ENERGY21

DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND



UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)

SOLARIS**THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS****ENERGY21****DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND**

[Content on this page supplied with permission from this web site of Jim Lux](#)

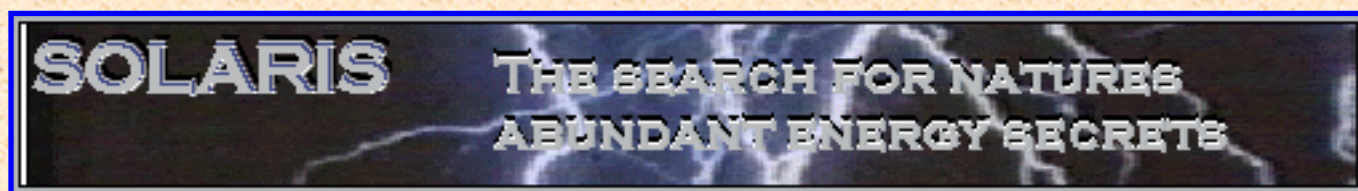
High Voltage Equipment Suppliers

Supplier	What they supply
Aerovox Aerovox Inc. 740 Belleville Avenue New Bedford, MA 02745 Telephone: (508) 994-9661 Fax: (508) 999-1000 www.aerovox.com	AC capacitors, DC film capacitors, aluminum electrolytic capacitors, power factor correction capacitors and systems, and EMI filters
Cornell-Dubilier now part of Aerovox (above)	
Cesiwid Corporation (formerly Carborundum Corporation) P.O. Box 339 3425 Hyde Park Blvd Niagara Falls, NY 14302-0339 Gary Innocenti - Applications/Sales (716)286-7608 fax: (716)286-7601	High voltage, high power non-inductive resistors, ceramic capacitors
Caton Connector Corporation Jones River Industrial Park 20 Wapping Road, Kingston, MA 02364 (617)585-4315, fax:(617)585-2973 www.caton.com	High voltage "Corona Free" connectors and cable

EG&G, Inc. Optoelectronics, ElectroOptics 35 Congress St Salem MA 01970 (508)745-3200 fax:(508) 745-0894 http://www.egginc.com/ .	Flash tubes, Hydrogen Thyratrons, Triggered and Overvoltage spark gaps, Trigger transformers, etc
General Electric, Silicones 260 Hudson River Road Waterford, NY 12188 (800)255-8886 www.ge.com	Silicones
HV Component Associates, Inc. P.O Box 2484 Farmingdale NJ 07727 (908) 938-4499, fax: (908)938-4451	HV Diodes, Voltage multipliers, Assemblies, Full-wave bridges
Jennings Technology Company 970 McLaughlin Avenue San Jose, CA 95122 U.S.A. PHONE: (408) 292-4025 FAX: (408) 286-1789 www.jenningstech.com	Capacitors (Vacuum & Gas Filled) Relays (Vacuum & Gas Filled) Coaxial Relays (Vacuum) Interrupters (Vacuum) Contactors (Vacuum) High Voltage Test Instruments Materials Analysis & Testing Services
Maxwell Labs, Balboa Division (Maxwell is reorganizing, so this might be different) 8888 Balboa Ave San Diego CA 92123 (619)576-7575 fax:(619)576-7672 http://www.maxwell.com/	Energy storage capacitors, Triggered spark gaps, Resistors, Marx Generators, etc.
National Electrostatics Corporation 7540 Graber Rd, PO Box 620310 Middleton WI 53562-0310 (608)831-7600, fax: (608)256-4103 http://www.pelletron.com/	Pelletron accelerators, charging systems, beam line components
QVR, Inc.QVR DESIGNS 17212 Pacato Place San Diego CA 92128 USA Fax at 619-592-0152 Phone at 619-592-0932 http://www.att.net/qvr1.pete/ Peter Naor , mail to: qvr1.pete@worldnet.att.net	Power Supply for Ion Sources in Ion Implanters. FLEXLINE Floating Output Power Supplies. Fiberoptic Links for control of floated power trains and instruments. High Voltage, Non-Inductive Encapsulated Resistors. Test Equipment for specific application Isolation Transformers for AC loads operating at high float voltages.

<p>Ross Engineering Corp 540 Westchester Dr Campbell, CA 95008 Fax to (408)377-5182 , Phone (408)377-4621 email: rosseng@aol.com</p>	<p>HV Relays, Safety Equipment</p> <p>designs, tests and manufactures high voltage devices for control, measurement and safety that are marketed both in the US and world-wide. Typical applications are in High Voltage power supplies, cyclotrons, lasers, radar, TV and high power communication transmitters, HV power line and underground cable voltage measurement and phasing, power quality and disturbance monitoring; for almost any HV equipment, industrial plant, laboratory or utility where high voltage or high current is utilized.</p>
<p>Science First 95 Botsford Place Buffalo NY 14216-2696 (716)874-0133 (800)875-3214 fax: (716)874-9853 info@sciencefirst.com</p>	<p>Van de Graaf Generator Kits, spun aluminum spheroids Formerly Morris & Lee, mentioned in dozens of Amateur Scientist Columns</p>
<p>Silpak, Inc 169 Atlantic St Pomona CA 91768 (909)595-6191 also in North Hollywood CA (818)985-8850 www.silpak.com</p>	<p>Silicone and other potting resins</p>
<p>Victoreen, Inc. 6000 Cochran Rd Cleveland, OH 44139-3395 (440) 248-9300 fax: (440)248-9301 www.victoreen.com</p>	<p>High resistance (1E12 ohms) precision resistors Geiger Muller tubes voltage regulator tubes</p>

Copyright 1998, Jim Lux/ supplier.htm / [Back to High Voltage Main Page](#) / [Back to home page](#) / [Mail to Jim](#) (jimlux@earthlink.net)





UNABLE TO FIND IT HERE
TRY OUR NEW SEARCH PAGE
[CLICK HERE](#)



[Content on this page supplied with permission from this web site of Jim Lux](#)

References

Obviously, I didn't figure out all this high voltage stuff from scratch. Here is an annotated list of references that one might find handy. Unfortunately, many of these are out of print, so you'll have to check the library. I have tried to provide as much information as possible to help you track these down. Most of these references are standard works, so most good university libraries have a copy.

Craggs, and Meek, *High Voltage Laboratory Technique*, Butterworth Scientific Publishers, London, 1954

The publisher is now Butterworth-Heinemann. This is out of print, and the publisher does not hold the copyright, so it probably rests with the authors (or more likely, their heirs). This is the standard work in the area, a compendium of the state of high voltage art in the early 50's. The author's intention was to collect the currently available information, much of which was in German at the time, into one reference work (much as I am trying to do). Much of what Craggs and Meek have to say is still valid, although modern materials and components have improved the situation somewhat: rectifiers are almost invariably stacks of silicon diodes these days, although if you want a single device with a 300 kV PIV rating, a vacuum diode is hard to beat (rather than stringing 300 1000PIV silicon diodes in series).

Cobine, James Dillon, *Gaseous Conductors: Theory and Engineering Applications*, Dover Publications, New York, 1958. paperback, xx+600 pp, 5 3/8x8

This is out of print. Here is the back cover blurb, which describes the work quite accurately:

Almost upon publication, this work became known as an indispensable text and reference for electrical engineers, radio engineers, physicists, lighting engineers, students, instructors, and everyone concerned with gaseous conduction phenomenon associated with missiles, atomic energy and fusion processes, and atmospheric research. Now, corrected and with a new introduction by the author, its usefulness is greatly increased.

The author begins with a thorough exposition of the fundamentals necessary to an understanding of the engineering applications of gaseous conductors. The physical concepts of the kinetic theory of gases, atomic structure, ionization, and emission phenomena are carefully considered. He then undertakes a detailed development of the theory of space charges, the breakdown of gases, spark characteristics, glow and arc discharges. The engineering applications of discharge phenomena in circuit interrupters, rectifiers, light sources, oscillographs, etc., are treated in great detail and with full awareness of the important differences of approach between academic and industrial studies.

All the fundamentals developed have direct and important bearings on gaseous conduction, and Dr. Cobine, has maintained his determination to let the engineering viewpoint prevail even in his discussions of theory. Of particular interest is the separate detailed treatment of low-pressure arcs (following Langmuir and Tonks) and high-pressure arcs (following Suits), considerable study of gas-discharge light sources, circuit interruption, circuit constants, rectifiers (tube and steel tank types), and cathode ray oscillographs, and the investigation of the characteristics of corona with special attention to space-charge effects and Holm's analysis.

Somerville J. M., *The Electric Arc*, Methuen, London, 1959 (John Wiley & Sons, New York)
Dr Somerville neatly summarizes much of the information in the 600 pages of Cobine's work in a 150 page monograph. There isn't as much on dielectric breakdown or on the theoretical basis for arc characteristics, but overall, a readable book. This book has a nice section on the development of the spark channel.

Edgerton, Harold E., *Electronic Flash, Strobe*, MIT This book is still in print, and is fairly inexpensive at around \$20.

While the primary aim of this book is for xenon strobe lamps, there is a lot of useful information on initiating the discharge, as well as practical details on capacitor charging supplies, and so forth.

Frügel, Frank, *High Speed Pulse Technology*, Academic Press, 1965, two volumes
There is a newer edition of this book from 1970, with four volumes, which I have not yet seen. It is more common (some 300+ owners, according to the interlibrary loan desk). I assume it is better and covers even more. Frügel is "Dr. Pulse", and for him, everything, from killing snails in the garden and crushing aluminum beer cans to nuclear fusion, is a possible application of pulse technology. This is a most complete compendium, in large part translated from his earlier works in German, with

all sorts of useful information, particularly on basic design principles for things like capacitor banks and impulse transformers. Like Edgerton, Früngel did a lot with fast strobes (brighter, faster, bigger, etc.). Much of the book is a bit stilted, reading like patent applications (which I suspect a lot of it really is edited from), however, more than enough information is there to allow an "ordinarily skilled practioner of the art to duplicate the invention"

Lowden, Eric, *Practical transformer design handbook*, 2nd ed., Tab Books, Blue Ridge Summit, 1989, ISBN 0-8306-3212-3

This is a fairly useful book dealing with transformer design at a practical level without much theoretical detail. If you need to figure out what that surplus transfomer is, or make/modify one from scratch, this is the book you need. It takes the theoretical design information and puts it in a practical context, as well as providing a lot of "rule of thumb" information.

Naidu, M.S. and Kamaraju, V., *High Voltage Engineering*, 2nd ed., McGraw Hill, 1995, ISBN 0-07-462286-2

A textbook on HV engineering, with chapters on breakdown phenomena in gases, liquids, and solids, oriented towards practical application. Also has chapters on testing methods: sphere gaps, pulse generators, measuring techniques, etc. Quite a useful book with lots of practical data on commonly used materials.

Bazelyan, E.M. and Raizer, Yu. P., *Spark Discharge*, CRC Press, Boca Raton, 1998. about \$100. A pretty good book on the dynamics and theory of the development of long sparks (i.e. bigger than 30 cm), typically at voltages > 1 Megavolt. Has a good chapter on Experimental Techniques covering Marx and Fitch generators, measurement techniques, etc. It has a great picture of a 100 meter+ spark from a 5 MV impulse generator to a 130 kV transmission line. Now, there is "high voltage"!

Wildi, Theodore, *Electrical Machines, Drives, and Power Systems*, Prentice Hall, Englewood Cliffs, New Jersey, 2nd Ed, 1991 (There is a third edition out now) about \$50, ISBN 0-13-251547-4. This a good textbook on AC and DC power, three phase motors and generators, basic distribution, etc. It has good explanation of mutual inductance, leakage inductance, and other transformer parameters. It is very accessible in a qualitative sense without too much math, but does provide some mathematical rigor if required. Lots of very clear (in a pedagogical sense) illustrations and photographs. It doesn't delve too deeply into derivations, so, this isn't the book if you want lots of theoretical details of the electromagnetic theory of salient pole induction motors.

The following, I haven't yet seen, but have been told that they are useful.

Craggs and Meek, *Electrical Breakdown in Gases*, The Clarendon Press, Oxford, 1953

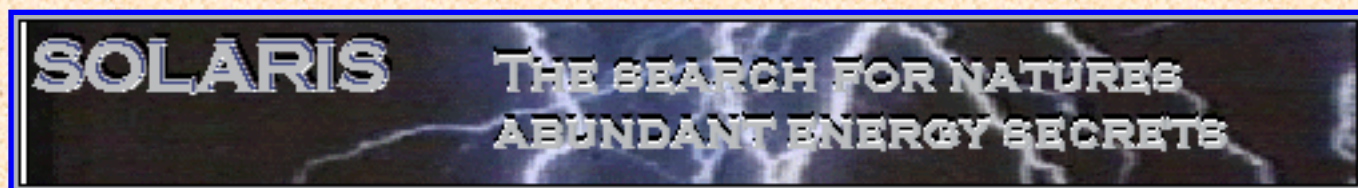
Gänger, B., *Der Elektrische Durchschlag von Gasen*, Springer-Verlag, Berlin, 1953 (English title: The Electrical Breakdown of Gases)

Schwab, A., *Hochspannungsmesstechnik (Messgeräte und Messverfahren)*, Springer-Verlag, Berlin,

1969. (The title, translated roughly, is *High Voltage Experimental Technique (Experimental equipment and Experimental procedures)*)

Lebacqz, J.V. and White, H.J. "The rotary spark gap," in *Pulse Generators*, pp275-292, McGraw Hill, New York, 1948. The Pulse Generators book is widely referenced, and probably has a lot of useful practical information derived in part from wartime research.

Copyright 1998, Jim Lux / revised 28 March 1998 / hvrefs.htm / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



SOLARIS

**THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS**

RUNNING CARS ON ZERO POINT / ORGONE ENERGY.



The car experiments were carried out on

Please take note the photographs were taken from a video showing a test unit made of glass and stainless steel to give you some idea of what the units look like ,Later and better units were said to have been made totally out of stainless steel (food grade only).

A plastic unit was claimed to have been constructed but was discontinued due to possible dangers involved.

This danger was found to have been avoided when units were constructed in rigid stainless steel.

This is only a brief overview and description of the JOE device.

It seems to have some things in common maybe with the Stanley Meyers concepts but does not seem to need the complex electronics that Stan is said to have used, and also it seems that the Joe's unit can be built by anyone with access to food grade stainless steel and some home workshop tools.

[more recent info on the Joe cell as of June 6 1999](#)

The ability to run cars without fuel of any type has been claimed to have been done and is claimed also to have been demonstrated here in Australia although I haven't seen it myself apart from the video



The test unit mounted in the car the normal fuel line was removed notice the reading on the vacuum gauge

The person that discovered this device also has claimed to have been harassed and threatened by some idiots and maybe vested interests.

They also stole all of these 'Wizards' gear out of his shed. It only goes to show, it is gutless idiots that do this type of stuff. They must want us all to die from pollution and poisoning.

The inventor's name has not been released to me apart from being called Joe.

I will call him the 'WIZARD'.

This person's work is along the same lines as William Reich.

[more recent info on the Joe cell as of June 6 1999 and of William Reich website locations](#)

BASICS of the invention:

When a automotive engine runs on a fuel, the incoming air's characteristic frequency changes because it interacts with the fuel. As the fuel travels along the manifold with the air it starts to spread (ATOMISATION) this give a greater contact area with the air .



The unit under test on the work bench notice the negative terminal at bottom of jar and the twin positive leads in the top of open glass jar and connected to stainless cylinders.

When the mix is in the chamber and the spark plug fires the air returns to its low frequency, releasing energy.

Some of the gases in the air have to react with the fuel to lower the fuels energy state. This is the pollution bit.

What if we could increase the frequency and the energy of the incoming air without fuel. That would mean NO pollution in the end process.



another view of glass test unit mounted in automobile

This is what the 'Wizard' has done. The device is simple in principle, but without the right knowledge of the materials required and the correct characteristics of each material it will not work. The cell consists of stainless steel tubes 1,2,3,4 inches in diameter a outer casing again Stainless steel 5 inches in diameter no welding can be done any where on the unit.

The ends should be dome type and presses on to the outer case when complete. The top has a 3/4 inch hole tapped in it to allow a aluminium delivery tube to be screwed in. The bottom has a hole drilled in it to allow a electrode to pass through the case without electrical contact.

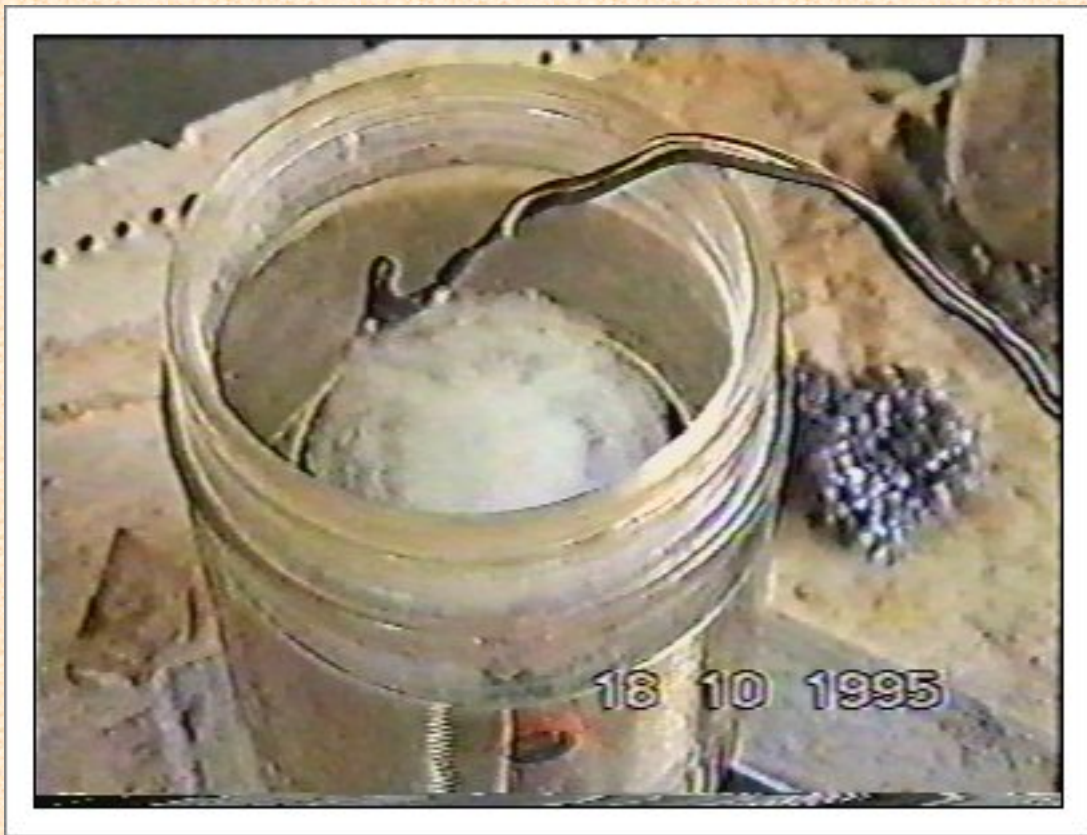


close up view of the glass unit prior to being charged

All insides of the tubes should be as polished as possible without the use of chemical or abrasive or steel brushes.(elbow grease and vinegar) The inner tubes are insulated from each other and the 1 inch one is connected to the bolt through the bottom.

The delivery tube and outer case must be isolated from the rest of the car. The deliver tube runs towards the carby or throttle body. At about 4 inches from the air metering device(carby or throttle) the aluminium stops and a piece of rubber hose connects to BLANK fitting on the device without hose clamps.

The cell is filled with specially charged water and the timing is adjusted over a couple of days . At the end the fuel is cut off all together and the motor will be running with a advance between 25 and 80 degrees. Castiron engines are the hardest to do.



This photo taken just a current is being applied notice the gas bubbles being formed, a few seconds later the entire glass is filled with a white mass of bubbling foam

Aluminium is the easiest to do. Some aluminium engines one take a day of driving to completely cut over. The exhaust is ice cold, the radiator has ice on it and it has twice the power of a petrol engine. I believe it may be worthwhile to remove the water from the block and replace it with Auto Transmission Fluid as it freezes at a much lower temperature.

I would expect that the water pump vanes would need to be clipped or drilled to decrease efficiency and drag in the oil. The bolt on the bottom is connected to the chassis. This may seem too simple but if done correctly it works.

I am currently working on my VN commodore and my other project is a turbocharged intercooled 13B rotary. I do not know what is going to happen with the turbocharged engine.

If I can make it work there will not be an engine that couldn't be converted including diesel's (replace injectors with spark plugs and electronic timing unit about \$440). Imagine ever truck and car in Australia using no fuel creating no pollution.

A wonderful place, however the government and fuel companies will do every thing that they can to stop us the people. I thought that they are our servants.(I wish)

This cell functions as a tree does, it is a biocapacitor or a self charging capacitor like the "ARK of Covenant" to stop the charging you must enclose the capacitor in Aluminium.

Added Benefits: Your car will not rust the paint will not oxidise the oil will last many times longer

the energy around the car will keep you healthy and heal your ills.

WATER:

The water used must be as clean as possible and alive (none treated water) once it is energised via a special process the water can be used in the cell.

All the impurities will be removed with this process that uses low voltage electricity.

There has been some other written work on this subject however I believe that none of the money raised by the sale of this information has been given to 'Wizard' to help recover from his losses.

They do give him credit but he should get something for his trouble. This idea alone could be worth Billions world wide. The 'Wizard' has many other wonderful inventions however the world may not be ready for them yet.

[more recent info on the Joe cell as of June 6 1999](#)

[An Analysis if the Joe Cell from a Biodynamics Perspective](#)

Stainless Steel Specifications

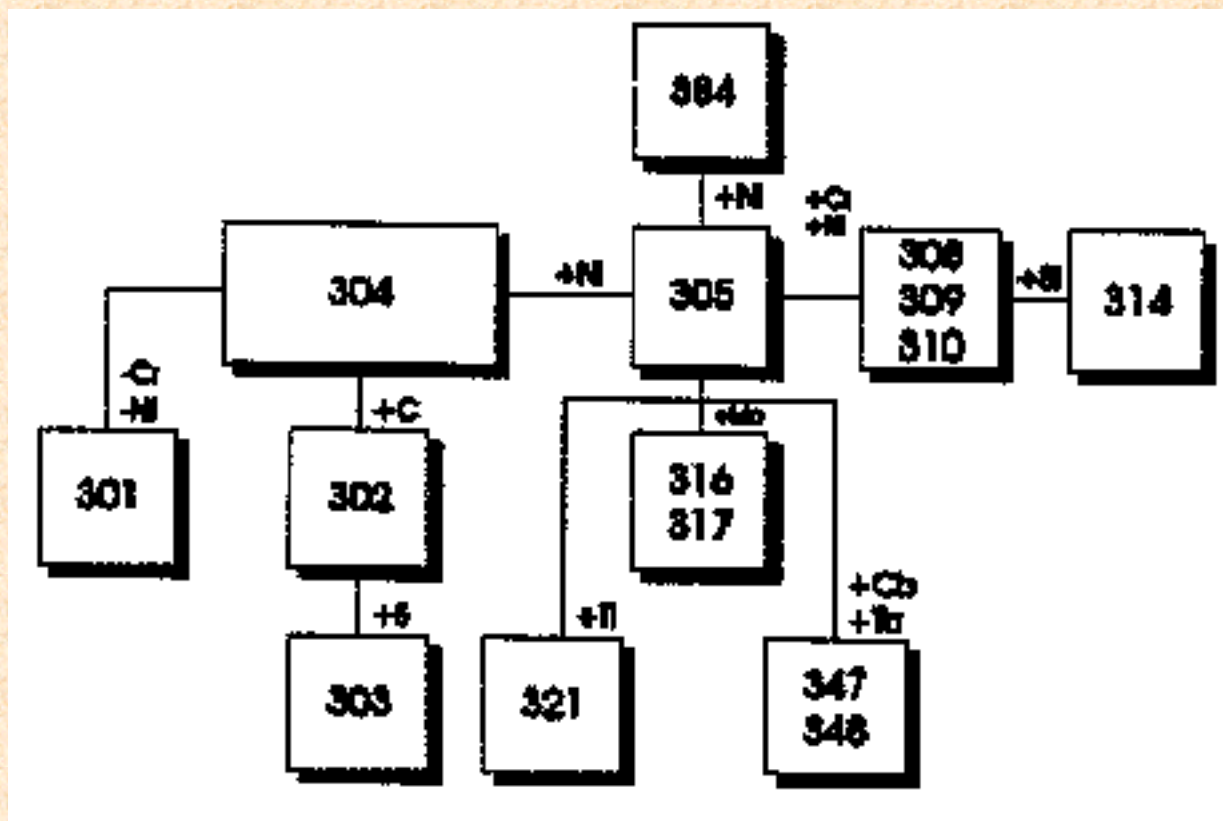
As Copied from http://www.sppusa.com/reference/white_paper/wp_ss.html

As Joes devices uses a special grade of stainless steel it may be of interest to intending builders of the device to know the differences and types

Stainless Steel

Stainless steel is primarily when corrosion or oxidation are a problem. The function that they perform cannot be duplicated by other materials for their cost. Over 50 years ago, it was discovered that a minimum of 12% chromium would impart corrosion and oxidation resistance to steel. Hence the definition "Stainless Steels", are those ferrous alloys that contain a minimum of 12% chromium for corrosion resistance. This development was the start of a family of alloys which has enabled the advancement and growth of chemical processing and power generating systems upon which our technological society is based. Subsequently several important sub-categories of stainless steels have been developed. The sub-categories are austenitic, martensitic, ferritic, duplex, precipitation hardening and super alloys.

Austenitic Grades



Austenitic grades are those alloys which are commonly in use for stainless applications. The austenitic grades are not magnetic. The most common austenitic alloys are iron-chromium-nickel steels and are widely known as the 300 series. The austenitic stainless steels, because of their high chromium and nickel content, are the most corrosion resistant of the stainless group providing unusually fine mechanical properties. They cannot be hardened by heat treatment, but can be hardened significantly by cold-working.

Straight Grades

The straight grades of austenitic stainless steel contain a maximum of 8% carbon. There is a misconception that straight grades contain a minimum of 3% carbon, but the spec does not require this. As long as the material meets the physical requirements of straight grade, there is no minimum carbon requirement.

"L" Grades

The "L" grades are used to provide extra corrosion resistance after welding. The letter "L" after a stainless steel type indicates low carbon (as in 304L). The carbon is kept to .03% or under to avoid carbide precipitation. Carbon in steel when heated to temperatures in what is called the critical range (800 degrees F to 1600 degrees F) precipitates out, combines with the chromium and gathers on the grain boundaries. This deprives the steel of the chromium in solution and promotes corrosion adjacent to the grain boundaries. By controlling the amount of carbon,

this is minimized. For weldability, the "L" grades are used. You may ask why all stainless steels are not produced as "L" grades. There are a couple of reasons:

"L" grades are more expensive

Carbon, at high temperatures imparts great physical strength

Frequently the mills are buying their raw material in "L" grades, but specifying the physical properties of the straight grade to retain straight grade strength. A case of having your cake and heating it too. This results in the material being dual certified 304/304L; 316/316L, etc.

"H" Grades

The "H" grades contain a minimum of 4% carbon and a maximum of 10% carbon and are designated by the letter "H" after the alloy. People ask for "H" grades primarily when the material will be used at extreme temperatures as the higher carbon helps the material retain strength at extreme temperatures.

You may hear the phrase "solution annealing". This means only that the carbides which may have precipitated (or moved) to the grain boundaries are put back into solution (dispersed) into the matrix of the metal by the annealing process. "L" grades are used where annealing after welding is impractical, such as in the field where pipe and fittings are being welded.

Type 304 The most common of austenitic grades, containing approximately 18% chromium and 8% nickel. It is used for chemical processing equipment, for food, dairy, and beverage industries, for heat exchangers, and for the milder chemicals.

Type 316 Contains 16% to 18% chromium and 11% to 14% nickel. It also has molybdenum added to the nickel and chrome of the 304. The molybdenum is used to control pit type attack. Type 316 is used in chemical processing, the pulp and paper industry, for food and beverage processing and dispensing and in the more corrosive environments. The molybdenum must be a minimum of 2%. Type 317 Contains a higher percentage of molybdenum than 316 for highly corrosive environments. It must have a minimum of 3% "moly". It is often used in stacks which contain scrubbers.

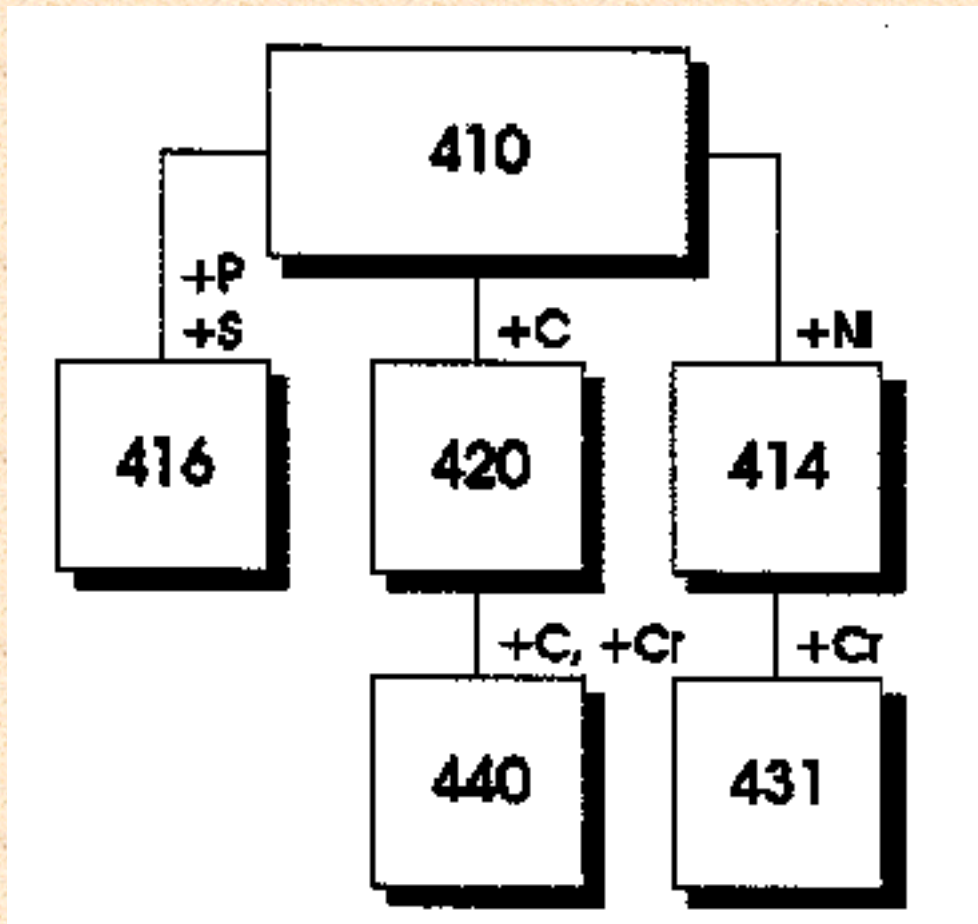
Type 317L Restricts maximum carbon content to 0.030% max. and silicon to 0.75% max. for extra corrosion resistance.

Type 317LM Requires molybdenum content of 4.00% min

Type 317LMN Requires molybdenum content of 4.00% min and nitrogen of .15% min Type 321

Type 347 These types have been developed for corrosive resistance for repeated intermittent exposure to temperature above 800 degrees F. Type 321 is made by the addition of titanium and Type 347 is made by the addition of tantalum/columbium. These grades are primarily used in the aircraft industry.

Martensitic Grades



Martensitic grades were developed in order to provide a group of stainless alloys that would be corrosion resistant and hardenable by heat treating. The martensitic grades are straight chromium steels containing no nickel. They are magnetic and can be hardened by heat treating. The martensitic grades are mainly used where hardness, strength, and wear resistance are required. Type 410 Basic martensitic grade, containing the lowest alloy content of the three basic stainless steels (304, 430, and 410). Low cost, general purpose, heat treatable stainless steel. Used widely where corrosion is not severe (air, water, some chemicals, and food acids). Typical applications include highly stressed parts needing the combination of strength and corrosion resistance such as fasteners.

Type 410S Contains lower carbon than Type 410, offers improved weldability but lower hardenability. Type 410S is a general purpose

corrosion and heat resisting chromium steel recommended for corrosion resisting applications.

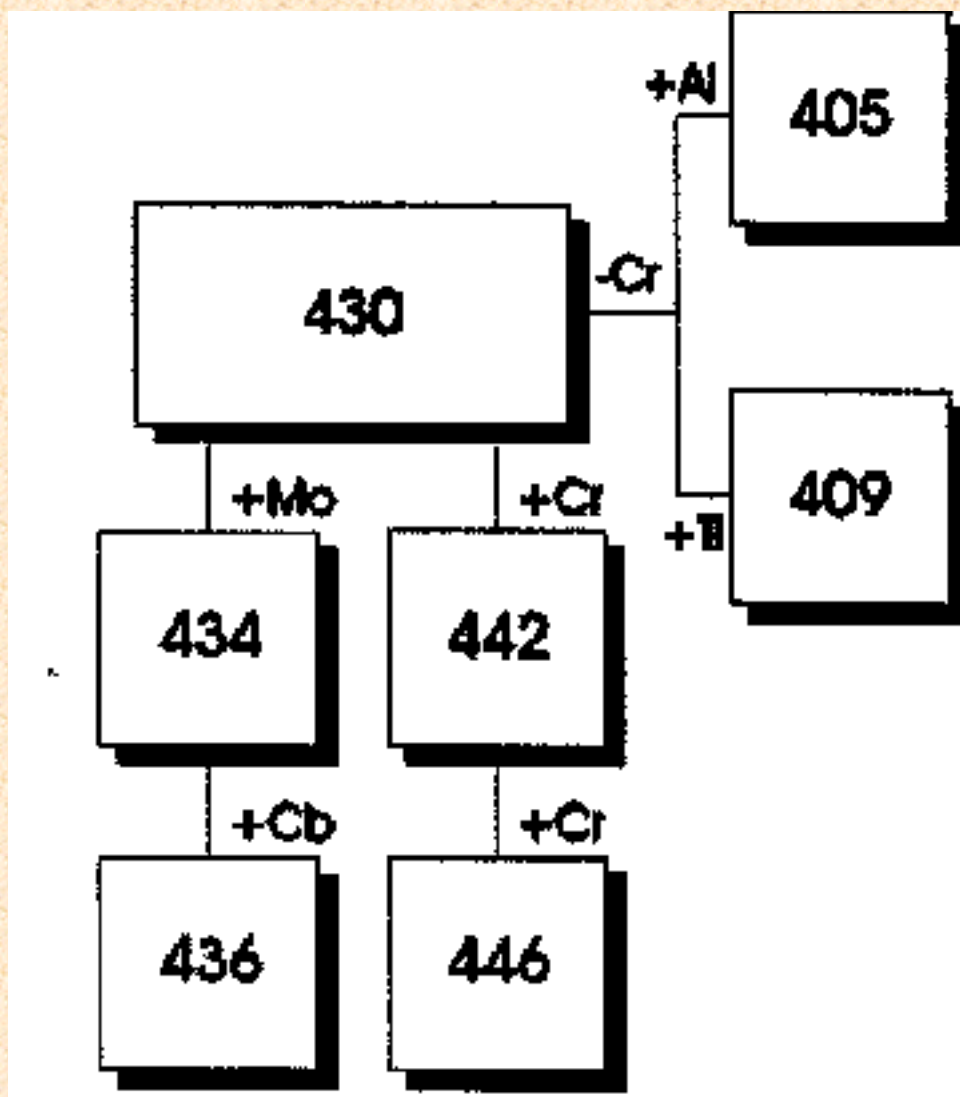
Type 414 Has nickel added (2%) for improved corrosion resistance. Typical applications include springs and cuttlery.

Type 416 Contains added phosphorus and sulfur for improved machinability. Typical applications include screw machine parts.

Type 420 Contains increased carbon to improve mechanical properties. Typical applications include surgical instruments.

Type 431 Contains increased chromium for greater corrosion resistance and good mechanical properties. Typical applications include high strength parts such as valves and pumps. Type 440 Further increases chromium and carbon to improve toughness and corrosion resistance. Typical applications include instruments.

Ferritic Grades



Ferritic grades have been developed to provide a group of stainless steel to resist corrosion and oxidation, while being highly resistant to stress corrosion cracking. These steels are magnetic but cannot be hardened or strengthened by heat treatment. They can be cold worked and softened by annealing. As a group, they are more corrosive resistant than the martensitic grades, but generally inferior to the austenitic grades. Like martensitic grades, these are straight chromium steels with no nickel. They are used for decorative trim, sinks, and automotive applications, particularly exhaust systems.

Type 430 The basic ferritic grade, with a little less corrosion resistance than Type 304. This type combines high resistance to such corrosives as nitric acid, sulfur gases, and many organic and food acids.

Type 405 Has lower chromium and added aluminum to prevent hardening when cooled from high temperatures. Typical applications include heat exchangers.

Type 409 Contains the lowest chromium content of all stainless steels and is also the least expensive. Originally designed for muffler stock and also used for exterior parts in non-critical corrosive environments.

Type 434 Has molybdenum added for improved corrosion resistance. Typical applications include automotive trim and fasteners.

Type 436 Type 436 has columbium added for corrosion and heat resistance. Typical applications include deep-drawn parts.

Type 442 Has increased chromium to improve scaling resistance. Typical applications include furnace and heater parts.

Type 446 Contains even more chromium added to further improve corrosion and scaling resistance at high temperatures. Especially good for oxidation resistance in sulfuric atmospheres.

Duplex Grades

Duplex grades are the newest of the stainless steels. This material is a combination of austenitic and ferritic material. This material has higher strength and superior resistance to stress corrosion cracking. An example of this material is type 2205. It is available on order from the mills.

Precipitation Hardening Grades

Precipitation hardening grades, as a class, offer the designer a unique combination of fabricability, strength, ease of heat treatment, and corrosion resistance not found in any other class of material. These

grades include 17Cr-4Ni (17-4PH) and 15Cr-SNi (15-5PH). The austenitic precipitationhardenable alloys have, to a large extent, been replaced by the more sophisticated and higher strength superalloys. The martensitic precipitation-hardenable stainless steels are really the work horse of the family. While designed primarily as a material to be used for bar, rods, wire, forgings, etc., martensitic precipitation-hardenable alloys are beginning to find more use in the flat rolled form. While the semiaustenitic precipitation-hardenable stainless steels were primarily designed as a sheet and strip product, they have found many applications in other product forms. Developed primarily as aerospace materials, many of these steels are gaining commercial acceptance as truly cost-effective materials in many applications.

Superalloy Grades

Superalloys are used when 316 or 317 are inadequate to withstand attack. They contain very large amounts of nickel and/or chrome and molybdenum. They are usually much more expensive than the usual 300 series alloys and can be more difficult to find. These alloys include Alloy 20 and Hastelloy.



Online Section



SOLARIS

THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS



[Content on this page supplied with permission from this web site of Jim Lux](#)

Some practical electrostatic calculations

It is often instructive to see a practical application of theoretical principles, so here are some examples:

- [Maximum voltage on the Science First\(tm\) 400kV Van de Graaf generator](#)
- [Capacitance and stored energy of the 400 kV Van deGraaf](#)
- [Force from the 400 kV Van de Graaf on a grounded sphere](#)

Maximum voltage on the Science First(tm) 400kV Van deGraaf generator

One limit on the maximum voltage that a Van deGraaf generator can reach is when the electric field strength at the surface of the sphere exceeds the breakdown for the insulating gas it is immersed in. The section on Van deGraaf generators describes other limitations such as arcing down the belt. For small demonstration type generators operating in room air, however, the E field limit is usually applicable.

Field at surface of a sphere = Voltage / Radius of Sphere

So, we use the handy approximation of 30 kV/cm for the breakdown strength of air and rearrange the equation a bit to get:

MaxVoltage = 30 kV * Radius(cm)

The classic Franklin Lee Van deGraaf from Scientific American has an upper electrode about 14 inches in diameter which actually has a minimum radius of curvature of about 7 inches (it is a "squashed" sphere).

$$\text{MaxVoltage} = 30 \text{ kV/cm} * 17.5 \text{ cm} = 525 \text{ kV}$$

The generator is advertised as reaching 400 kV, which is probably a realistic assessment, given that it isn't perfectly smooth and that there is an insulating column between the sphereoid and the ground plane at the base.

Capacitance and stored energy of 400 kV Van deGraaf

While the upper electrode on that Van deGraaf isn't perfectly spherical, we can probably approximate it as one to calculate the capacitance and stored energy. Note that here, we'll use the real radius of the sphereoid, as opposed to the breakdown voltage calculation, where we used the smallest radius of curvature.

$$r = 7 \text{ inches} = .178 \text{ meters}$$

$$C_{\text{sphere}} = 4 * \pi * \epsilon_{\text{air}} * r = 111.2 \text{ pF/meter} * .178 \text{ meters} = 19.8 \text{ pF}$$

Now, let's calculate the stored energy: Is it a crack or a bang when we discharge it?

$$\text{Energy} = 0.5 * C * V^2$$

$$\text{Energy} = 0.5 * 19.8\text{E-}12 * 4\text{E}5^2 = 1.5 \text{ Joules}$$

(A handy form of the energy equation is: Energy (Joules) = $1/2 * C(\text{microfarads}) * V(\text{kilovolts})^2$. The units nicely cancel.)

Force from 400 kV Van deGraaf on a grounded sphere

Pretty much the first thing people do when they get a demonstration Van deGraaf is to make sparks from the upper electrode. When I did this, I was amazed at the electrostatic force on the grounded electrode I was discharging to. It is one thing to intellectually know about Columb forces, and another to feel them in your arm muscles (or to watch them move the electrodes around). As it happens, calculating the field between two conducting spheres is a non trivial task because the charge isn't evenly distributed. However, let's approximate (since experiment will determine the exact number, we only need to know if it is a tiny force or a huge one).

At 400 kV, the gap between the spheres will be a minimum of 10-15 cm. Let's use 15 cm spacing of 15 cm radius spheres for the calculation. A first order approximation will use Coulomb's law, and treat the sphere as a point charge at the center. First question: How much charge?

$$q = CV = 19.8\text{E-}12 * 400\text{E}3 = 7.920\text{E-}6 \text{ Coulombs}$$

I've approximated C as a sphere in free space, which certainly isn't the case, but will do for an order of magnitude calculation

Now, let's use Coulomb's law

$$F = 1/(4*\pi*\epsilon) * q_1 * q_2 / r^2 = 1/111.2\text{E-}12 * 7.92\text{E-}6 * 7.92\text{E-}6 / (.45^2) \\ = 2.78 \text{ Newtons (approximately)}$$

About a half a pound, which is more than you would expect at first glance.

Copyright 1997, Jim Lux / 14 Sep 1997 / statcalc.htm / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)





[Content on this page supplied with permission from this web site of Jim Lux](#)

Supplemental information on Paschen's Law, equations, breakdown in gases.

This is really rough, still....

Paschen's Law reflects the Townsend breakdown mechanism in gases, that is, a cascading of secondary electrons emitted by collisions in the gap. The significant parameter is pd , the product of the gap distance and the pressure. Typically, the Townsend mechanism (and by extension Paschen's law) apply at pd products less than 1000 torr cm, or gaps around a centimeter at one atmosphere. Furthermore, some modifications are necessary for highly electronegative gases because they recombine the secondary electrons very quickly.

In general, an equation for breakdown is derived, and suitable parameters chosen by fitting to empirical data.

Here are three equations:

Breakdown voltage:

$$V_{\text{breakdown}} = B * p * d / (C + \ln(p * d))$$

Breakdown field strength:

$$E_{\text{breakdown}} = p * (B / (C + \ln(p * d)))$$

where:

$$C = A / \ln(1 + 1 / \gamma)$$

where:

γ is the (poorly known) secondary ionization coefficient.

For air:

$$A = 15 \text{ cm}^{-1} \text{Torr}^{-1}$$

$$B = 365 \text{ Vcm}^{-1} \text{Torr}^{-1}$$

$$\text{and } \gamma = 10^{-2}$$

so

$$C = 1.18$$

above data taken from [Bazelyan](#), p.32

Minimum sparking potential for various gases

Gas	Vs min (V)	pd at Vs min (torr cm)
Air	327	0.567
Ar	137	0.9
H2	273	1.15
He	156	4.0
CO2	420	0.51
N2	251	0.67
N2O	418	0.5
O2	450	0.7
SO2	457	0.33
H2S	414	0.6

data from [Naidu](#), p.27

Note that the sparking voltage is affected by the electrode material, with cathodes of Barium and Magnesium having higher voltages than Aluminum, for example.

Temperature dependence

Paschen's law ($V = f(pd)$) should really be stated as $V = f(Nd)$ where N is the density of gas molecules, which is, of course, affected by the temperature as well as the pressure of the gas ($n/V = p/RT$). An empirical formula for air is:

$$x = 293 * p * d / (760 * T)$$

$$V_{\text{breakdown}} = 24.22 * x + 6.08 * \text{SQRT}(x)$$

Gamma - Townsend's secondary ionization coefficient

Gamma is the net (!) number of secondary electrons produced per incident positive ion, photon, excited or metastable particle. It is a function of gas pressure and E/p. Electronegative gases (SF6, Freon, oxygen, CO2) reattach the electrons very quickly, so they have low gammas.

For nitrogen, gamma ranges between 10^{-3} and 10^{-2} for E/p of 100-700 V cm⁻¹ torr⁻¹. Insulating gases like SF6 or Freon have gammas of 10^{-4} or even less.

A further reference for information would be [Cobine](#).

Copyright 1998, Jim Lux / paschen2.htm / 28 March 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



The word "SOLARIS" in a stylized, metallic, blocky font.The text "THE SEARCH FOR NATURES ABUNDANT ENERGY SECRETS" in a metallic, blocky font.The text "ENERGY21" in a stylized, metallic, blocky font.The text "DISCOVERING NATURES POWER SECRETS FOR 2000 AND BEYOND" in a metallic, blocky font.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Reasons not to use wirewound resistors beyond their ratings

At first glance, the readily available wirewound power resistor appears to be a good solution to inexpensive high voltage resistor requirements. The breakdown voltage is typically several kilovolts per inch of length, so a 100 watt resistor 6 inches long will probably work at 20 kV, particularly for an application where the substantial inductance isn't a problem. However, in systems where there is a lot of stored energy, the failure mode for these resistors can cause catastrophic damage to other components.

A wirewound resistor is made by winding a very fine resistance element (e.g. Nichrome) on a ceramic form. If a small open develops (the typical failure mode, either due to a physical impact deforming or severing the wire, or due to excessive power dissipation) an arc will form at the gap, melting the wire back, making the arc bigger. This is a continuing process that can be quite spectacular.

Copyright 1997, Jim Lux/ resww.htm / [Back to Resistor page](#) / [Back to High Voltage Main Page](#) / [Back to home page](#) / [Mail to Jim](#)
(jimlux@earthlink.net)

The text "UNABLE TO FIND IT HERE TRY OUR NEW SEARCH PAGE CLICK HERE" in a metallic, blocky font.

**SOLARIS****THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS****ENERGY21****DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND**

[Content on this page supplied with permission from this web site of Jim Lux](#)

Water Resistors

The quest for inexpensive resistors that can handle high voltages and energies leads to what are known as "water resistors". A water resistor is essentially a tube filled with a salt solution and an electrode at each end. You can control the concentration of the salt to control the resistance, for a given size tube.

There are three basic types of resistor required in a high voltage system. They differ primarily in their required resistance: tens/hundreds of ohms, 10K-20K, and multi megohms. The very high resistance, high voltage resistors are used in voltage dividers to measure multi hundred kilovolt signals without destroying your test gear. The really low resistance units (around a hundred ohms) are used as load resistors for an impulse generator, or to control the circuit Q. Finally, the middle range, 10K-20K are used as charging resistors to limit the current. The last two applications require handling a fair amount of energy, often with very high peak powers.

Copper Sulfate is popular as the salt, since it doesn't corrode copper (or copper alloy, i.e. brass) electrodes. I started using PVC water pipe and some surplus copper bolts, but found that you always wind up with air bubbles and sealing problems. As the temperature changes, the air in the bubble expands and contracts creating leaks. Also, the resistance is orientation sensitive, as the bubble moves around changing the conductive path (in fact, they use this effect in sensitive electronic levels).

My latest scheme is flexible tubing (e.g. vinyl (Tygon) or polyethylene) and brass machine screws. I've also used brass hose barbs, but they have a hole in the middle which you have to seal, although in some cases this might actually be an advantage. You stick the tube into a bucket of salt solution, fill it up and, keeping it submerged, shove/screw in the bolts. Don't use steel or cad plated hardware or the copper sulfate will react, plating out on the steel, and leaving sludge in your resistor. I haven't looked into aluminum electrodes and soluble aluminum salts, but I suppose it would work.

Why not use brass or copper rod as the electrode? There aren't those handy barbs or threads to aid in sealing the bolt to the tubing. For better sealing, you could use crimp-on brass ferrules as used in air hoses and the like. You could use a screw hose clamp like they use on radiator hoses, but the edges on the clamp will doom you to corona problems, unless you are going to pot the whole assembly,

which raises all sorts of other problems.

You don't need the purest reagent grade copper sulfate for this either. Regular old technical or purified grade is sufficient. It runs about five or six dollars per pound. The kind with lumps is harder to dissolve, and costs more to boot (they use it for killing tree roots).

Water resistor design calculations

When designing your water resistor, you need to decide on the diameter and length, and then you adjust the salt concentration to get the value you need. As a practical starting point for your calculations: A 1 meter length of 1/4" id tubing filled with 0.1 Molar Copper Sulfate (1.6 g in 100 cc water) has a measured resistance of 39.8 Kohms.

You want to keep the diameter up fairly large (> .25 inch) to reduce corona problems. A more critical issue for high energy (e.g. Marx Generator and capacitor dump) applications is making sure you won't melt the hose with the heat dissipated in the resistor. You need to calculate how much volume you have, its thermal capacity, the thermal resistance of the plastic, etc.

Sample calculation:

10 kJ pulses every minute.

Handy conversions: 1 kJ = 240 calories (approx)

Vinyl tubing is good to around 90 degrees C, so our maximum temperature rise is 40 degrees above an assumed ambient of 40 degrees.

1 cm ID (3/8") tubing, 50 cm long. Approximately 35 cc of salt solution, or 35 g, assuming specific gravity of 1. We'll also assume a specific heat of 1 degree/cal. The delta T for this resistor is 7 degrees C per kilojoule. If you are dissipating 10 kJ per pulse, you are looking at a 70 degree rise, which will probably melt the tubing. Even if you use a meter of tubing, doubling the volume, you are still looking at a 30 degree rise. A 200 cm length gives you a 16 degree rise.

Try 1.9 cm (ID) diameter tubing. A 50 cm length is 153 cc, or about 1.6 degree per kilojoule, which is much better. Our design 10 kJ pulse now results in a delta T of 16 degrees.

How fast will this heat be carried away? The primary limiting thing is the thermal resistance of the tubing wall, nominally .125 inches (.3175 cm) thick. You need to figure with the mean logarithmic area which is about 350 sq cm. The thermal conductivity is about .003 W/cmK. So:

Watts = $.003 * 350 / .3175 * 16 = 52.5$ watts at 16 degrees above ambient.

Log mean diameter = $(od - id) / \ln(od/id)$

$$= (2.535-1.9)/\ln(2.535/1.9)$$

$$= 2.2 \text{ cm}$$

Log mean area = $\pi * \log \text{ mean diam} * \text{length}$

$$= 3.14159 * 2.2 * 50$$

$$= 350 \text{ (approx)}$$

At this rate it will take some 200+ seconds for the water to cool back down from a 10 kJ pulse.

Going back to another case, the 1cm ID (3/8 nominal) with 1/16" walls, a 200 cm long piece with a 16 degree rise dissipates about 250 watts, for a time constant around a minute, which is getting reasonable.

You can continue this process and figure out the most cost effective approach, given that bigger diameter terminal bolts cost more. Tubing runs anywhere from .10/ft to 1.00/ft, depending on the diameter. 3/8" id runs around .33 /ft, so the 2 meter piece is about \$2.00, add another \$2 for the two terminal bolts, and you have a resistor for around \$4, plus a bunch of labor. Even if takes you an hour to make a resistor, compared to the \$100 for the commercial item, this isn't a bad deal. Not like making capacitors, where you spend a lot more time for an inferior product.

Another calculation

A water resistor can also be used as a high power load resistor. For instance, when testing my Marx generator (40 kJ at 600 kV), I need a repeatable load that can handle the energy without a lot of noise and fuss. For this application, you are looking at a total resistance of a few hundred ohms, and a lot more volume to absorb the energy without appreciably heating. I started with a provisional design of a 2 meter length of 3 inch diameter PVC pipe. The thermal calculation runs as:

Volume of liquid: 9.1 liters

Thermal transmission area: 5000 sq cm

Temp rise: .026 deg/kJ

Thermal Resistance: 47.5 Watts/degree

Time constant: 810 seconds

So, for my 40 kJ pulses, I expect the liquid to gain about a degree. If I were to hit the load with a pulse every 5 minutes (i.e. avg power of about 130 Watts), the system would reach thermal equilibrium at a temperature rise of about 3 degrees, certainly reasonable for the plastic.

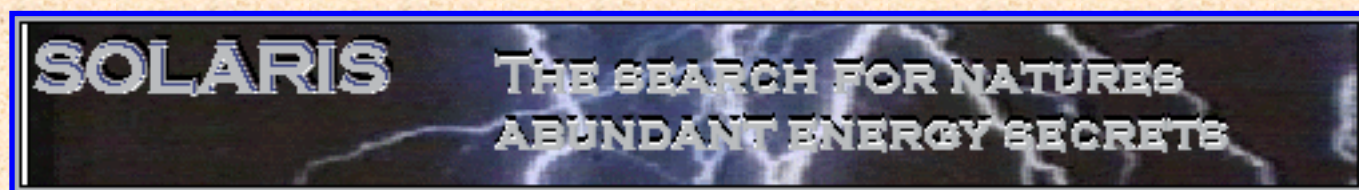
There are some practical details with electrodes on something of this scale, making sure you don't have a current concentration that causes localized heating at a rate faster than convection can distribute it through the electrolyte.

A high resistance voltage divider

For purposes of measuring high voltages from low current sources (like a Van deGraaf generator), it is nice to have a resistor of thousands of megohms which can stand a megavolt or so. For this, you need a very small diameter tube, and lots of it. You can also use almost pure distilled water, since you probably want something like 1 Megohm cm resistivity. For instance, 10 meters (1000 cm) of 1 sqcm tubing filled with 1 Mohm cm water would be a 1000 Meg resistor. The problems that will creep in here is the gradual change in the conductivity of the water due to ions from the electrodes. One way to solve this is to circulate the water through the system and continuously deionize it with a cartridge deionizer. Actually, if you are building a voltage divider, you probably don't care what the actual resistivity is, just that it be uniform. A pump to circulate the water would fix this. With high resistance values, you have to be concerned about dirt on the outside of the tube getting damp from atmospheric moisture and the leakage path being lower resistance than your resistor.

Another problem with high resistance water resistors is that the resistivity of water, itself is zero for DC, that is, it gradually polarizes and electrolyzes. For AC signals, this may not be a significant problem. Distilled water has been used in pulse forming capacitors and transmission lines that only remain charged for a microsecond or so quite successfully. The high dielectric constant of water (85) makes it attractive in these applications.

Copyright 1997, Jim Lux/ resww.htm / [Back to Resistor page](#) / [Back to High Voltage Main Page](#) / [Back to home page](#) / [Mail to Jim](#)
(jimlux@earthlink.net)



**SOLARIS**THE SEARCH FOR NATURE'S
ABUNDANT ENERGY SECRETS**ENERGY21**DISCOVERING NATURE'S POWER
SECRETS FOR 2000 AND BEYOND

[Content on this page supplied with permission from this web site of Jim Lux](#)

ElectroOptical Theory

Kerr

The Kerr effect results from the impressed electric field causes the assymetric molecules of the liquid to align with the field. This causes the liquid to become anisotropic and birefringent. The change in index is given by:

$$n_o - n_e = K * E^2 * \lambda$$

where:

λ is the wavelength of the light

E is the electric field strength

K is the Kerr constant

A Kerr Cell is a cell containing the liquid (typically Nitrobenzene) between two flat parallel plates spaced several millimeters. A fairly high voltage (typically 10-20 kV) is placed on the plates..

If the field is such that the cell retards the extraordinary ray by a half wavelength, the polarization rotation will be 90 degrees. If a pair of polarizers is put around the cell, oriented at 45degrees, the assembly acts as a shutter. The voltage required to do this is called the "halfwavelength voltage".

At the half wave voltage, the following is true.

$$(n_o - n_e) * d = \lambda / 2$$

where

d is length of cell

other variables as above.

Note that the wavelength cancels out when rearranging and substituting to give:

$$E_{\text{halfwave}} = \sqrt{1 / (2 * d * K)}$$

for calculating the halfwave E field

$$d = 1 / (2 * K * E^2)$$

for calculating required length of cell

Sample Kerr Constants

Nitrobenzene	2.4E-10 cm/V ²
Glasses	3E-14 to 2E-23 cm/V ²
Water	4.4E-12 cm/V ²

For Nitrobenzene (K=2.4E-10 cm/V²) and 30 kV/cm (breakdown of air), d = 2.3 cm

Pockels

$$(n_o - n_e) = pE$$

where E is the applied field, and p is a proportionality constant:

A similar calculation to that for Kerr cells can be made to determine the half wave voltage for the cell.

KDP (Potassium Dihydrogen Phosphate)	3.6E-11 meter/Volt
Deuterated KDP (KD*P)	8.0E-11 meter/Volt
Lithium Niobate (LiNbO ₃)	3.7E-10 meter/Volt

Faraday

$$\text{Rotation} = VBl$$

where

Rotation in radians

V is Verdet Constant

B is the magnetic field strength

l is the length

Verdet Constant (if l in millimeters, B in Tesla)

fused quartz	0.004
dense flint glass	0.11
Benzene	0.0087

A peculiarity of Faraday rotation is that it rotates the same direction (e.g. Clockwise or Counterclockwise) no matter which direction the light is travelling. This can be used to make a one way light valve with two polarizers set at 45 degrees to each other.

Copyright 1998, Jim Lux / eotheory.htm / 8 March 1998 / [Back to HV Home](#) / [Back to home page](#) / [Mail to Jim](#)



The word "SOLARIS" in a stylized, metallic, blocky font.A banner with a dark background and a blue lightning bolt. The text "THE SEARCH FOR NATURES ABUNDANT ENERGY SECRETS" is written in a metallic, blocky font.The text "ENERGY21" in a stylized, metallic, blocky font, with the "21" in red.A banner with a dark background and a blue lightning bolt. The text "DISCOVERING NATURES POWER SECRETS FOR 2000 AND BEYOND" is written in a metallic, blocky font.

[Content on this page supplied with permission from this web site of Jim Lux](#)

Example Transformer Measurements and Calculations

This page has some actual measurements and calculations on GE Type 5021G10 transformer, which was originally intended for an illumination power supply for a copier. It has a lot of leakage reactance to limit the current. The nominal specs are 120V input, 4500V output, 400mA short circuit output current. This transformer is interesting because it has a third winding, nominally 600V, for connecting a capacitor for power factor correction. At rated output, this transformer draws about 8.5Amps, i.e. about 1kVA

Open Circuit Tests

- Primary Voltage: 118V
- Primary Current: 5A
- Active Power to Primary: 69.6W
- Secondary Voltage: 4415

Short Circuit Tests

- Primary Voltage: 68V
- Primary Current: 5A
- Active Power: 40.7W

Calculated:

Reactive Power 585.9 Vars

Magnetizing Circuit R: $200 + j23.76$ Ohms

Series equivalent: $1.628 + j13.5$ Ohms



More recent information on the Joe cell

Our other websites.

[Our Solaris website](#)

[Energy 21](#)

[Brightsparks](#)

[Part one of the joe cell "](#)

I have recieved two pieces of information about the joe cell

One positive one extremely negative.

I have placed both here for you to make up your mind and offer no personal comment as I am now uncertain about these claims.

The first one is as follows

Ian Hacon the guy who sells the Joe cell phenomena book and video has sent me this additional info on the joe cell device.

Date: Thu, 03 Jun 1999 23:47:27 +1000

[From: Ian Hacon](#)

Dear folk

Nutech are releasing this vital information on the Joe cell. A researcher is publishing a new book based on his research and practical experience.

He has 4 cars running on Joe cells and has made a marvellous contribution in making this technology understandable and has developed the methodology etc.

This is Breakthrough information, so I hope you will all make good use of it for the betterment of mankind. The book will contain photographs of each stage of the cell coming to life and full and

detailed procedures.

We know some have found this project frustrating, while many have had success to some degree. Either running totally or doubling mileage. We wish you every success.

Ian of Nutech

Chapter 1.

" Since corrupt people unite amongst themselves to constitute a force, then honest people must do the same"

Count Leo N. Tolstoy.

Introduction.

Intention.

My intention, (to the best of my ability), is to remove some of the mystery, secrets, guesswork and plain mis-information that surrounds the construction of the " cell ". The aim is to help the constructor make a cell in a laid out step by step method that I employ to make my own cells. My knowledge comes from making the cells. As I have built many working cells, this experience has given me the knowledge, not by guesswork or reading someone's book or listening to second or third hand " expert " opinions. I now pass this information on to you. And it will always stay as my opinion and information, until you build your own cell. Only then will you know how to make a cell and not before!

Joe

In approximately 1992 a new form of a generator was constructed in Australia. In preparation for this book, I spoke to both the designer and his fiancée, regarding my wish to give him the due credits etc., for his 7 years of work and cooperation with all involved parties. Unfortunately due to the lunatic fringe and money grabbers that dealt with him, this poor, victimised individual has decided to relinquish any further involvement with the cell that bears his name. So in respect to his wishes, he will simply be referred to as Joe.

I would simply like to say dear Joe, that if it was not for rare individuals like you, we the vast brain washed majority would never find the true beauties of mother natures gifts.

It is now probably too late to save mother earth from the years of pollution and desecration caused by the thoughtless money grabbing multi nationals. As a species we are unique. Even a little simple bird keeps its nest clean, yet we the most intelligent of creation destroy our only home! Yet, individuals

like Joe show us that there is a better way, a simple pure way, nature's way. Without the benefit? of years of dogmatic mind shrinking education, Joe found by intuition how to ask nature a question in such a way that it answered. The answer was a method of powering machinery without the use of our primary resources or the creation of pollution. This method is well known to the select few and the technology has been around for centuries. Joe has made a crude version of this generator. The generator is called a Joe cell.

What is a Joe cell?

find out, let us look at some of the characteristics of the cell as stated by Joe.

- * The water in the cell is not consumed.
- * The cell runs cold to the touch.
- * It takes a period of time before the engine will run from the cell. It then has an erratic power output and works in an intermittent fashion.
- * When the cell is removed from the car, the engine takes an appreciable time to return to " normal " and run from the original fuel.
- * If the cell is left in the car for a long period, the engine becomes " charged ". From this point, the cell is not required for the motor to run.
- * All spark plug leads can be removed and the engine will still run as long as the ignition coil and distributor remain functional.
- * The output of the cell, does not have to be connected to the internals of the engine, a close external coupling will do.
- * The cell requires the " charging " of the water to work.
- * The " charged " water can be poured from one container to another without losing the " charge ".
- * The cell requires a specific style of construction, little understood by most constructors.
- * An empirical construction style has evolved with little, if any science or success.
- * The source of power for the cell and its use has great value for some individuals. These
- * individuals are creating mis-information, cloaking operations and fear to the cell constructors.
- * Human presence can affect the operation of the cell in a positive or negative way.

There is much more information on the Joe cell that is available to the privileged few, but we have enough information from the above clues to identify the energy type. From the above it is plain to see that, without a shadow of a doubt in my mind, the Joe cell is a crude Orgone accumulator, and that the cell runs on, or collects Orgone. There is a 100% correlation with Orgone energy and its properties. As these accumulators have been and are in use all over the world, the constructor can share in this vast pool of knowledge. He can bypass the myths, mis-information and the mongers of secrets and get on with scientifically based facts. Also he can be prepared to realise and meet the DANGERS that await the rash and fool hardy.

Chapter 2. ORGONE.

As all known effects of Orgone are seen in the functioning of a Joe cell, it is reasonable to assume that the reader should have a good working knowledge of Orgone energy. Additionally, as the cell obeys all known Orgone laws and as the cells operation does not contradict even one Orgone effect, it is safe to assume that this is the energy that is utilised in the cell.

In honour of, and respect to one of the worlds' great scientists, namely Wilhelm Reich, I will continue to use the name Orgone as used by Reich. A multitude of other scientists great and small have given it a name. In a following chapter I have listed at least 80 names by various individuals that is the same or similar force.

Orgone energy is the live cosmic energy of nature. To quote Reich ,.....The Cosmic OR Energy fills the universe.....and.....it is a spontaneously pulsating, mass-free energy.....

For interested readers, there is a huge collection of facts, opinions and absolute rubbish on the Internet regarding Reich and Orgone. As the aim of this book is to focus on the Joe cell, the above definition will suffice.

Some properties of Orgone energy

Thousands of properties have been observed for the life force and I would like to list and explain the main ones relating to the cell.

1. It is mass free. ie. Orgone energy has no inertia or weight etc. So conventional test equipment that requires a reaction or something to " push " against to measure a force will be ineffective.
2. It is present everywhere. But, more importantly to the Joe cell user, the concentration is variable from place to place and from time to time. Therefore if the cell is leaky and located in a low concentration area, it may stop breeding or even loose the seed. The external signs are a motor that will not produce full power or will not run at all.
3. It in constant motion. It has an uneven movement from West to East at a speed considerably greater than the earths rotation. The motion is a pulsating expansion and contraction and a flow

normally along a curved path. Inside an accumulator, the energy is emitted as a spinning wave. Both of these can be seen to varying degrees in a charging vat and or cell. These signs are very important to the experimenter as they are his tools in the different stages of seeding and breeding of the cell.

4. It negates the laws of entropy. Orgone energy flows from lower concentrations to higher concentrations ie. Orgone attracts concentrations to itself. This is the normal process of creation and as such is a proof of Orgone being a living energy. For the experimenter this is very important especially in the seeding stage. If the cell is located in an unfavourable location, it may not seed or take a long time to seed. I have had cells taking 4 weeks to seed, others take only a few days.

5. Matter is created from it. Under appropriate conditions, which are not rare or unusual, I have had different minerals formed from identical cells. This in my case is usually a white or green powder that forms as very fine colloid that eventually sinks to the bottom of the cell. You definitely do not want this to occur in the Joe cell as the cell will not run the car and the only solution is to completely dismantle, repolish and clean all components. For the sceptical you may assume that the deposits are coming out of the water. I strongly disagree.

6. It can be manipulated and controlled. We do this in the cell by forming alternate organic and non organic " cylinders " to form an accumulator for the Orgone. Thus the organic layers attract and soak up the Orgone and the metallic layers draw it from the organic material and radiate it into the interior of the accumulator. Additionally we use electricity, magnetism and electrolysis to assist with the breeding process.

7. It comes from the sun in vast quantities. As such, allowing for thermal lag, the Orgone density peaks in the afternoon and diminishes in the early morning hours. As people have found, a leaky cell will not function or " die " around 3 am to 4 am.

8. It is affected by weather, ie. humidity, cloud, temperature and time of day affects the accumulation of Orgone. For the experimenter with a leaky cell this explains the weird behaviour of leaky cells ie. sometimes they work other times not, but if you stand on one foot, talk to it, try different water, chemistry, more or less power etc. it will " come good ". This has created a whole religion of what you must do or not do, to such an extent that with the blind leading the blind, the cell in the hands of a casual constructor is doomed to failure.

9A. It moves in the direction of a magnetic field. This is highly significant to the cell builder. This factor controls the position and polarity of the cell's internal wiring as well as controlling how much residual magnetism the steel can have and still allow the cell to work. This is critical in the choice and cutting operations of the related metals, Again a whole mythology has developed around this area . From reading previous material on the subject, it seems that the steel has to be cut by vestal virgins in the Black Forest on a moonlit night!

9B. It moves at right angle to an electrical field. Again highly important as it dictates polarity and wiring connection to the cell.

10. It is absorbed by water. This is why we use water in the cell. Of course the water has to be the

right type of water. By the way, for example, we could have used bees wax, but as we want to encourage the breeding process with all the tricks in the book, the bees wax would have prevented the use of electrolysis.

11. It is polarised. As Orgone is polarised we can build a positive or negative cell. But, if you mix your positive and negative construction materials as most people do, then your result is a leaky or non operational cell.

12. It will penetrate or travel along all known materials. All bodies of continuous structure are equally good conductors eg. It may travel through 70 feet or more of metal. As such do not think that you are trapping it in the cell. The only reason it stays in the cell at all is because it wants to. It is up to the experimenter to set up a seeding and breeding environment that is conducive to Orgone and not try to create an imaginary prison.

13. It has a slow conduction rate. Orgone will take 20 seconds or more to traverse 50 yards of wire. For the experimenter this means that you should wait about 30 seconds on turning power on to the cell before you can expect to observe Orgone induction.

14. It exhibits a constant upward tendency, raising vertically. Highly important in creating a non leaky cell installation in an car.

15. It cannot remain in steel or water longer than about 1 hour. Simply said, if you cell is not breeding, it will die in about 1 hour. This explains the use of a 1.5 volt battery across leaky cells to maintain a breeding process.

16. It radiates a great distance. From a typical cell the radiation circumference is at least 160 feet. Think about it!

17. It follows optical laws. It can be refracted by a prism etc. This explains the reason for the mirrored or highly polished surfaces in some parts of the cell. It also allows us to control some leaking by utilising optical laws.

18. It surrounds itself with alternating spherical zones of opposite polarity. This is utilised by us to determine cylinder diameters and consequential spacing in the optimisation of the cell.

19. It is affected by living beings. Again important as the experimenter and his attitude can interact with the cell

20. It can only be concentrated to a finite amount. If a cell is charged to its maximum degree so that it can hold no more, it will transform itself into electricity and in this way or form find a discharge. By the visual observation of the bubbles and surface tension of the water, we utilise this fact to our advantage.

Chapter 3.

Comparative names for the life force

At no stage do I even remotely hint that the following terms are identical. The purpose of the list is to show the many names given to unexplainable forces of which Orgone is one.

Manna of the Polynesians. Nervous Ether. Richardson.

elan-vital. Henri Bergson. X-Force. L. E. Eeman

vis medicatrix. Hippocrates. Bio-cosmic energy. Dr. Oscar Brunler.

vis naturalis. Orgone Energy. Dr. Wilhelm Reich.

mumia. Paracelsus. Prana. Hindus.

Vital Fluid. Alchemists. Akasa. Hindus.

Animal magnetism. Mesmer Brahma. Hindus.

Magnetic Fluid. Mesmer. Manna. Israelites.

Odic Force. Baron Karl Von Reichenbach. Virtue. Jesus.

Ka. Egyptians. hika. Egyptians.

Universal life force. Baron Eugene Ferson. Life Force. Dr. Aubrey T. Westlake.

Cosmo-electric energy George Starr. Reiki. Japanese.

Ethertricity. Gaston Burridge. telesma. Hermes Trismegistus.

Pneuma. Gallien. Astral light. Kabbalists.

Spiritus. Fludd. Eckankar.

baraka. Sufis. mungo. African.

entelechy. Dreisch. Ch'i. Chinese.

Bioplasma. Russians. Arealoha. Francis Nixon.

Psychotronic energy. Czechs. Biotronic. Czechs.

Kirlian effect. kerei. Indonesians.

tondi. Sumatra. Eloptic energy. T. Galen Hieronymus.

Ether. Aristotle. tinh. Annamites of Vietnam.

elima. Nkundu. dynamis. Ancient Greeks.

Numen. Romans. El. Hebrews.

Fermi Energy. Orenda. Iroquois.

Manitou. Algonquian. Wakan. Sioux.

Wakonda. Omaha. Maxpe. Crow.

Digin. Navaho. Dige. Apache.

Hullo. Chickasaw. Neutrino sea. P. A. A. Dirac.

Fluoroplasmic energy. B. Hilton. Biodynamic Ether. Rudolf Steiner.

Eloptic radiation. Hieronymus. Logoital plasma. Hieronymus.

neutral force. Kabbala. Negative entropic energy. James DeMayo.

Scalar energy. Tachyon energy.

Vril. Latent neutral. Keely.

Neutricity. Gallimore. Pure non manifest energy. Todd R. Knudtson.

G-field. Sir Oliver Lodge. Space energy.

Cosmic energy.

Chapter 4.

Orgone polarity.

As Orgone is polarised, either positive or negative, Orgone can be manifested sometimes as both

polarities for a short period of time.

In our search for the perfect Joe cell, it is essential to utilise polarity conducive materials in the construction of the cell. With the use of suspect materials that encourages the creation or retention of both polarities, the cell is not only a poor breeder ,but also leaky.

I would strongly encourage the experimenter to choose to construct either a negative or positive cell and not to use materials at random or what happens to be handy or cheap. This is a sure way to failure.

Positive Negative

Negative electricity Positive electricity

Iron Selenium

Copper Sulphur

Tin Iodine

Lead Palladium

Brass Cobalt

German silver Phosphorus

Alkalies Tellurium

Alkaloids Charcoal

Argentinium silver Evaporation

Mercury Steaming

The base, (non pointy end), of crystals Dstillation

Friction Sound

Magnetic South Vibration

Left hand Right hand

Running water Tip of crystal

Bismuth Magnetic North

Zinc Acids

Osmium Decomposition

Titanium Oxides

Potassium Haccoid salts

Calcined lime Chemical reaction

As seen from the above short list, chemical reaction, in our case electrolysis, evaporation, steaming, vibration, sound and acids are the most common goings on in the cell and in the car. To rephrase, since the natural events in our cells habitat favour the acid cell, I would suggest that the experimenter builds an acid cell until he gains the knowledge of the causes of the cell behaviour.

I personally only build acid cells. I have a dislike of the corrosion associated with alkaline cells and also find that the water remains crystal clear and the insulators do not fail in my acid cells.

Chapter 7.

" Nature is the embodiment of the simplest conceivable mathematics. "

Albert Einstein.

Seed Diameter/Height Ratio

To calculate the height of the cylinders for maximum efficiency, proceed as follows:

1. As covered in greater detail in the chapter on " Charging the water ", make sure that you have your chosen test current flowing through the cell. I normally adjust my electrolyte to obtain a repeatable current flow of 1 Ampere with 12 Volts across the cell.
2. Place a known voltage across the innermost cylinder and the outermost cylinder. For car use, I suggest 12 volts from a car battery or equivalent. The negative goes to the inside bottom of the innermost cylinder, (normally 1" diameter), and the positive goes to the outside top of the outermost cylinder, (normally 4" or 5" diameter). Measure this voltage accurately!
3. Now leave one lead of the volt meter on the inner cylinder and with the other lead, find the half voltage point diagonally from the inner cylinder to a point in the water. Do your best to memorise this point. Now place one lead of the meter on the outer cylinder and with the other lead, find the half voltage point diagonally towards the inner cylinder. Note this point it will be close to the first measured point, but not necessarily the same point ! If there is a difference halve the difference and

record.

4. Measure diametrically the distance from the center of the innermost cylinder to the half voltage point as measured plus the difference if any . Double this measurement! This is the diameter of the " seed " circumference. For example on a 4,3,2,1 cylinder cell the total diameter was 2.24" and for a 5,4,3,2,1 cylinder cell the total distance was 2.83"

5. By using the natural log of the height of the cylinder, we can interpolate and work out our optimum cylinder heights. I have worked out some standard size values for you. You can easily work out your value from the following table.

Height Seed	Height Seed
(cyl.) (dia.)	(cyl.) (dia.)

6"	1.79"	13"	2.56"
----	-------	-----	-------

6.5"	1.87"	13.5"	2.60"
------	-------	-------	-------

7"	1.95"	14"	2.64"
----	-------	-----	-------

7.5"	2.01"	14.5"	2.67"
------	-------	-------	-------

8"	2.08"	15"	2.71"
----	-------	-----	-------

8.5"	2.14"	15.5"	2.74"
------	-------	-------	-------

9"	2.20"	16"	2.77"
----	-------	-----	-------

9.5"	2.25"	16.5"	2.80"
------	-------	-------	-------

10"	2.30"	17"	2.83"
-----	-------	-----	-------

10.5"	2.35"	17.5"	2.86"
-------	-------	-------	-------

11"	2.40"	18"	2.89"
-----	-------	-----	-------

11.5"	2.44"	18.5"	2.92"
-------	-------	-------	-------

12"	2.48"	19"	2.94"
-----	-------	-----	-------

12.5" 2.53" 19.5" 2.97"

21" 3.00"

6

So in 4. above we would use inner cylinder of about 9.4" for the 4 cylinder cell and we would use 17" for the 5 cylinder cell. If this height is too long for you can use the next sub multiple for the longer cylinders ie. 8.5" for the 17" cylinder etc. There is a corresponding loss in " breeding " output, but as long as your cell is not too leaky and you are not travelling in a strip of low level Orgone you should get away with it.

7. At no stage should you use inner cylinders of a length of less than 7" of cylinder height for the most common cubic capacity car engines. Of course for test cells and lawn mowers etc. you will be able to get away with lower surface area cylinders.

Chapter 12.

Do not over analyse or over experiment.

This will destroy the experiment and it's creative Orgonomic force.

Dr. Wilhelm Reich

When things go wrong.

well, my dear reader, you are reading this section for alternative reasons, some are;

A. You always read a book or notes from cover to cover befer you start a construction project. Great, good idea, read on.

B. You are an armchair scientist and you are reading this information to see how it fits in with your own pet opinions on the subject. Good luck and I hope if you find something to contribute, you will do so freely and in brotherly love.

C. You are reading this chapter because you have made a cell by other methods and are looking for a quick fix. I would strongly recommend that you read and absorb all the previous chapters, as you may have a borderline cell and it may be better to construct a new cell.

D. You are here because you have followed exactly, all my suggestions, and you car will not run on the cell.

n the above, I am only interested in reader D.

Approach to the problem

All problems irrespective of complexity can be solved. in a methodical rational fashion If it looks insurmountable, break it down into convenient smaller section's that you can cope with. Have this smaller section cover one topic only. Make sure that you have a working knowledge of the topic. Take your time , and have somebody else to talk with regarding your chosen solution and approach.

It is important that you change one variable at a time only! If you change variables in a haphazard method or without recording you observations, at the end of the day, you will be worse of than when you started. I would suggest that you break up your problem into the following topics.

Fault finding topics

1. The water.

- 1a. Cell maintenance.

2. The cell construction.

3. The charging operation.

4. Cell to car interface.

5. Car modifications.

6. Geographic location.

7. Y factor.

1. The water

The single most common problem that you will encounter is the water. As Joe remarked on many times, the " water goes bad ". Not a scientific explanation but well said.

So, what are some of the problems with the water?

A. Is the water dead or polluted right from the start? If you collected, transported and stored the water personally, you should know its history. Re read Chapter 8. If you still doubt your water try the following. Orgone accumulates in water and as such, when you transfer the water out of the cell, you take the charge with it. Therefore, if you, or an acquaintance has a good, ie. stage 3 cell, the water can now be substituted into the suspect cell. On now powering up the suspect cell, within 1 minute you cell should be at stage 3. If the suspect cell does not come up to stage 3, the water is not at fault! The above is by far the easiest way to test a suspect cell, unfortunately you will need another cell or external help.

Note. Do not leave the charged water outside its cell for longer than 1 hour as it is not breeding.

B. Has the pH of your water changed? Simply run your pH test on the cell water. The reading should be the same. If not either the cylinders or the insulators are breaking down and reacting with the water and electrolyte. Make sure that you followed charging, insulator and cylinder material type recommendations.

C. Is the water clear? As in B., the cylinders or insulators are breaking down. Or the cell has gone into a base matter creation mode. As this topic is highly controversial and not pertinent to this subject, your only option is to completely dismantle, polish and clean the cell and or replace the insulators. Fill with fresh juvenile water. Go through charge stages as per Chapter 9.

D. Is there any residue in the sump? As in B. and C. above.

E. Are the stage 3 breeding indicators behaving the same? Read chapter 9 and make sure that the behaviour of the bubbles and meniscus are the same, especially the long term bubble retention. Again if all else fails try the voltage check.

F. Have you changed locations and the cell is now sitting in a low density Orgone strip? Make sure that the cell is at stage 3. Read Chapter 9.

G. Have you accidentally shorted out the cell or reversed polarity to it? See if it goes back to stage 3 if you apply power to it for 1 minute. If not dismantle, polish and clean all components. Fill with fresh juvenile water. Go through charge stages in Chapter 9..

H. Have you allowed the seed to die? Read Chapter 9. Go through stage 1, stage 2 and stage 3 process. The cell may go to stage 2 or even stage 3 within 3 minutes.

I. Has the cell fallen over at any stage? Try 1 minute charge and see if the cell goes to stage 3. If not, dismantle, polish and clean all components. Fill with fresh juvenile water. Go through charge stages in Chapter 9.

1a. Cell maintenance.

I have found after a cell has been in operation for about 6 months, although there is no external

indications of malfunction, ie. the cell is happily breeding, it is a good idea to do the equivalent of an oil change and grease. You may find one or more of the following;

- * There is a light deposit on the cylinders particularly the outside of the 1 inch and 2 inch.
- * The cylinders may have sagged from the vibration, ie. they are not flat on the top horizontal alignment..
- * If rubber insulators are used, you will find that they have developed a set.
- * Some of the insulators particularly the inner top ones may have a light white or grey deposit on them.
- * There may be a slight suspension or colloid towards the bottom of the cell.
- * There may be slight indications of a brown sediment on top of the water.
- * The cell metal parts may have become magnetised.
- * The lower insulators for the bolt may have shrunk and could be weeping.
- * The electrical connections to the cell may be loose or corroded.
- * The compression fitting for the aluminium pipe may be loose.
- * The short piece of rubber or neoprene hose to the blanking plug may have aged.

The cure for the above are self explanatory. The only difficult one is if the cell has become magnetised. You may be able to degauss the cell or at worst you may have to have the offending cylinder replaced or heat treated. When you demagnetise your cell find a better location for it, or it will only happen again!

I do a regular 6 month service on my cells. The steps I perform are as follows; I pour out the charged water into a 5 litre glass container and put it in a cool dark area. Obviously the glass cylinder is clean and only used for your Joe cell work! Remember you have approximately 1 hour to replace the charged water back into a seeding and breeding cell. I next dismantle the cell and clean all surfaces with mild acetic acid. I find that it is not necessary to repolish the cylinders, but you may do so if it makes you feel better. I rotate any rubber insulators 180 degrees so as to use a fresh surface with no set. I lubricate my bolt and associated insulators with Vaseline and reassemble the cell. By this time the charged water has been sitting for about 1/2 hour in the glass cylinder and the majority of the sediment has settled to the bottom of the glass container. I now pour the charged water back into the cell using a paper coffee filter to catch any sediment. I stop pouring the charged water into the cell,

when the first drops of water with the sediments starts to leave the glass container. This water I discard or have analysed to amuse myself. I now top up the cell with fresh juvenile water and connect the cell to the power supply. Within seconds you will see a fine white cloud develop on top of the water. This is the residue of the acetic acid that you used to clean the cell with. I remove this simply by wiping the top of the water surface with a paper towel. Within 1 minute your cell will be back at stage 3. That's it, you have just completed your 6 month service.

Note. I will repeat again in case you have forgotten, but all water, containers, funnel etc. must have only juvenile water used in the cleaning or transferring of water for the cell maintenance. It requires a very small quantity of tap water that has been "enhanced" by good old mankind to kill the cell. Don't blame me if you have to start at stage 1 again by being lazy.

2. The cell construction

Needless to say, you should have followed the cell construction Chapters to the letter. If you did not, you obviously know how to make a different type of cell, and these notes will not be 100% relevant, or you have chosen to be creative, frugal, haphazard, or slap happy at the wrong time. I repeat, you are not making a toaster! You are trying to induce the life force to work for you. You cannot capture the life force as in a cage. It will enter and exit as it sees fit. It can penetrate all materials!

If the cell was working at stage 3 and now will not work.

A1. A common problem is that the cell cylinders have moved due to rough handling, vibration, or the wrong diameter insulators. The fix is a dismantle and re alignment. Make sure that your hands are clean!

A2. Another common problem is the covering of the cylinders and insulators with various residues. This can be seen on the dismantled cell, as an easy removable film on the cylinders and insulators. In this case treat as a dead cell and dismantle, polish and clean all components after finding the cause of the problem. The usual causes are wrong welding material or flux, wrong cylinder material type, wrong insulator material type, or water problems as in section 1. above. Fill with fresh juvenile water and start at stage 1.

A3. The cell material has been magnetised by locating the cell near starter cables or other high current carrying wiring eg. Hi-Fi wiring, fog lamp or other types of ancillary lights wiring, winch wiring, etc. In this case find the magnetised component or components with your test magnet and replace or de-magnetise the affected components. A hot under bonnet location will cause similar problems. After fixing the cell relocate the cell or the offending items.

A4. The insulators or the cylinders are eaten away to some degree. You will pick this up in the discolouration of the water. If you followed my instructions this will not occur. The problem is incompatible steel or insulators with the water electrolyte combination. In any case treat the cell as dead, replace faulty components etc. as in A2

If the cell never worked at stage 3.

B1. The cylinder material type. As mentioned in Chapter 6, the material that you use is critical in your early learning stages. All 316L is not the same! Re read Chapter 6.

B2. The cell cylinder dimension is wrong. Re read Chapter 6 and Chapter 7. The cylinders must be level at the critical chamber separation area which are formed by the tops of the internal cylindrical tubes. Re check that the cylinders are level. You should see no light when measuring with a straight edge.

B3. The cylinder finish. As the top and bottom cuts are finished in a lathe, they should be absolutely smooth, ie. no file or cutting marks. Similarly there should not be any heat bands where the cylinders were cut. The surface of the rest of the cylinder does not have to be mirror smooth, but make sure that there is no longitudinal marks or scratches. If you followed Chapter 6, they will be Ok.

B4. Make sure that the welding is done as per Chapter 6. Make sure that all internal irregularities caused by the welding process are removed, without causing excessive localised hot spots.

B5. Make sure that all threaded couplings from the cell to the engine is metal to metal joints and the threads are not covered in sealants or Teflon tape etc.

B7. Make sure that the cell is air tight. If you apply your power source for a minute or two to the cell and block the outlet of the aluminium pipe with your finger only, you will feel the release of pressure on removal of your finger. Do not do this near flames and or explosive gasses! This will also check that your cell is not open circuit or shorted and that it is electrolysing.

B8. In B7 above, the most common electrical problems are the push fit of the 1/2 inch bolt into the 1 inch pipe, and the insulators between the 1 inch bolt and the lower cell exit point.

3. The charging operation

The failures can be sub divided into 3 sections;

A. Failure to get to stage 1. If you cannot get the water to electrolyse at all, you have not read Chapter 9. Even blind Freddie and his dog can do this. Hang your head in shame and take up another interest! Seriously, not many things can go wrong. If your power source is putting out about 12 Volts and if you have added the electrolyte as described, then you must have some bubble activity in the water. If still no bubbles in the water, connect a 12 Volt car globe of any type to the very ends of the leads that you are connecting to the cell. The lamp will light if your power source and your leads are Ok. Now remove the lamp and put the positive lead to the outside surface of the cell and the negative lead to the 1 inch bolt that connects to the 1 inch cylinder. If you still have no bubbles, the 1 inch bolt connection to the 1 inch tube is faulty, but highly unlikely. Re check the insulators that insulate the 1 inch bolt from the outer container. As there is now water in the cell you will not be able to do your insulation test but you should still read more than 10 Ohms resistance from the bolt to the case. Be careful of misleading readings if the cell is acting as a battery, as your Ohm measurement will be useless.

B. Failure to get to stage 2. By this I mean that the cell has not seeded and remains at the electrolysis stage. As explained, if the cell will not seed, the indication is there is no change in bubble size or surface tension. Boy oh boy, I have been here many a time myself and I suggest the following;

B1. The first and most common is the covering of the cylinders with a coating of various chemicals. In my early days, when I took the lazy way out and brazed or silver soldered my casing joints, this compound ended up all over the rest of the cell due to electrolysis. As the positive is the donor surface and the outer casing including welds, sealants etc., this fact aggravated the plating process.

B2. Another failure and resulting contamination, was the use of the wrong type of sealant on the central insulator for the sealing of the 1/2 inch bolt where it passes out through the bottom of the cell.

B3. Likewise, when I decided to press fit my outer cell components, I used an automotive silicon gasket cement on the joints. This also ended up plating the whole cell.

B4. If the water smells un-healthy or there is scum floating around, the water has gone bad. Replace with fresh water and go back to stage 1.

B5. Check that your insulators have retained the original manufactured colours. That is, if red rubber, make sure they are still red, if silicone tubing, make sure it is still clear etc. The insulators may be fine for stage 1 electrolysis, but may be very leaky to Orgone.

B6. Your working area or you may be detrimental to the seeding of the cell. See 6. and 7.

B7. You are not covering the cell overnight and or between experiments. As previously explained, we want to keep a very mild air seal on the cell. This is easily done by placing a lid on the test cell or by having a spare aluminium plug in the end of the hose where it fits onto the engine fitting. Again I must repeat, DO NOT. use worm drive clips on both ends of the rubber coupling sleeve. The rubber sleeve must act as a one way exit for any pressure in the cell. The internal cell pressure must remain very close to atmospheric during operation.

B8. You are just too impatient! It may take 4 weeks to seed the cell! Just spend a few minutes a day with it and go and do something else.

B9. You have used the wrong materials. This has already been covered. Please read 2.

B10. You have used the wrong water. Ditto. Please read 1.

B11. You are using the wrong charging method. Ditto. Please read 3.

Note. For all problems in this section due to contamination of the cell by deposits, water or materials, dismantle the cell, polish, clean and refill with juvenile water.

C. Failure to get to stage 3. This is the failure of the cell to breed. Again to repeat, this is the failure

of the cell to keep increasing the initial seed density to a greater but still finite Orgone energy limit. Indicators will be a lack of long term bubble and surface tension retention and an obvious non operation or marginal operation. Usually you will get to stage 3 very soon ie. within days of stage 2. Another way of describing the failure of running at stage 3, is that the cell is leaky to such an extent, the Orgone force cannot accumulate sufficient density for our need's.

C1. The most common fault of the cells in not breeding, or insufficient breeding, is caused by marginal water, construction dimensions and materials. Please make sure that you have followed these notes to the letter. If you have modified or substituted components etc., you obviously know something that I do not know and if your cell had worked, I would love to hear from you. But as you are reading this and if you cell is not working, I suggest you follow my instructions to the letter, or try somebody else's, " how to build a Joe cell " book.

C2. Your working are or you may be detrimental to the cell's operation. Read 6. and 7.

4. Cell to car interface.

If you are looking for faults in this area, you know that you cell is at stage 3, but the engine refuses to run from the cell.

A1. Outlet pipe from cell.

A lot of different diameters and materials will work. I would suggest, like Joe that you use 20 mm. aluminium pipe. Due to electrolytic action copper will either pollute the cell, or pollute itself. The short piece of rubber or neoprene must not have any clips on the end that attaches over the blind aluminium plug. The idea is to let any pressure " burp " out, but not to let any air in. The fitting should act as a one way valve to pressure from the cell caused by the electrolytic action. The engine end of the aluminium pipe should have you Positive electrical connection secured to the pipe by means of the same short piece of hose being slipped over it. This end should have a clip to squeeze the hose and the electrical fitting to the pipe. What you are doing is providing your Positive connection at the very end of the outlet pipe. You Negative of course will go to the cars body, (we are presuming a modern car that has a Negative earth system). The pipe fitting to the top of the cell must be air tight without the use of sealants or Teflon tape etc. The compression fitting will do a good job of this. Try to twist the aluminium pipe out of the compression fitting, if tight, you will not be able to budge it. You pipe should also have some form of insulation around it to prevent contacts to the rest of the metallic parts of the car. Ideally, the cell should be similarly protected. Remember, just one short circuit and the cell is dead!

A2. Electrical connections. The Positive wire coming from the end of the aluminium pipe should go via a 5 Amp fuse to you " ignition on " wiring. By this I mean that the cell should only have the car power connected to it when the ignition is on. Some people prefer to run this wire via an off/on switch that is located in the car. When you connect your Negative to the car, it is preferable to connect it directly to the block if you earth straps from the motor or gearbox are suspect. Either way, with the ignition on, you should measure 12 Volts Positive on the cell body and 12 Volts Negative on the central bolt fitting. If not check you wiring, fuse, any switches, etc. The most probable cause of

no Voltage is a blown fuse because you have shorted the cell. Find you short, replace the fuse and make sure that the cell goes to stage 3. If not, pull the cell out clean, polish, new water etc. ie. start again. The other most common problems are the use of sealants on the compression fitting. This is easy to find and fix. If you have 12 Volts across the cell, that does not mean necessarily that you have your 1 Amp current flow. To check this, temporally disconnect the Negative end of your cell from the car body or motor and put you Amp meter in series with the central bolt and the car connection. You should read your 1 Amp current flow. If not you have some high resistance connection's or wiring or the cell is faulty. As you are reading this because you know you cell is not faulty, the problem is either you aluminium pipe connection or you wiring. Locate the problem step by step, making sure that you do not short out or apply reverse polarity to the cell.

A3. Cell design. If you have made a cell with the wrong taper to you cone, the Orgone will focus before it gets to the motor and the cell will work brilliantly on the bench, but it will not run the car. The only reason this has occurred is that you did not build a cell as described in these notes.

A4. Cell location. Check as previously explained that the cell is located in a favourable location in the car. Is it in a cool place? is it level? Is it located as far as possible from high current wiring. Is it located in a low vibration area? Not like some rocket scientist who strapped it to his engine!!! As Orgone has a vertical preference once it leaves the cell, reduce horizontal pipe runs to a minimum. A cell located in the boot, with a 4 meter run to the engine is not a great idea. Again, a non leaky cell can run 60 meters or more into a horizontal tube, but why tempt fate? As far as the cell (but not the passenger) is concerned, for you first cell temporary location, the passenger foot well, with a pipe through the bulk head and a short, (less than a meter) pipe to the plug located at the rear of the engine (non V8) works well.

Note. At this point of the trouble shooting list, you know that you cell is at stage 3 and that it is connected correctly to the car. So if things are still not working, leave this area alone! Do not undo what you know is working ie. Don't dismantle your cell or associated connections to the car, they are Ok.! Leave them alone and look for problems in the only remaining areas you have not covered, ie. Section 5, 6, and 7. Unless you keep a systematic approach to the installation and trouble shooting you will never get the cell to run the car.

5. Car modifications.

For a start, I will again state the obvious, some cars will be easier to modify than others. Or more importantly, not all persons will be able to modify all cars! So unless you are masochistic and want to make your friend's life a misery, choose an easy car! This of course may not be old faithful that is sitting in your garage. You should also have followed Chapter 10. before you read this.

You are reading this because, you KNOW that your cell is still breeding, ie. running at stage 3, your car connections are ok. and you electrical connections are ok. You have started your car on petrol and after it has warmed up, you either have turned of the electrical fuel pump, or you have turned of the fuel to or from the mechanical pump. Now as the fuel is used up in the fuel bowl or bowls the engine falters and stops, (at this stage, I am not talking about fuel injected motors). That is how I would expect you to test the change over phase. You are really pushing your luck, if you walk up to a stone

dead car, remove the fuel to the engine and start cranking! I hope you have plenty of fully charged batteries!

The car will either run, run erratically or not at all.

1. Car shows no sign of running from the cell. By this I mean, that as soon as the motor runs out of fuel it stop. A lot of people get here, but blame the wrong components. As stated above, you are here because you know all sections up to here are working ok. This only leaves this Section and 6 and 7. So lets presume that the car is at fault as that is the present topic.

I can tell you for a fact, that a 1971 V8 Rover will start first shot and run like a dream, likewise a 1100cc Mini Minor will not even think of starting first time. Why? There is a lot of pet theories floating around but as these are my notes I will give you my theory based on logic.

Note, the following is a theory and eventually may be proven wrong. but the way I see it is, that the water and the cylinder bores in the motor act as a single layer Orgone accumulator, ie. an Organic material, (water), surrounding a non Organic cylinder, (the bore). As such an engine with a bore that is fully surrounded with water will be far superior than an engine that uses siamesed bores or casting methods, without the benefit of the totally water surrounding cylinder. Now as most aluminium blocks have metal sleeve cylinders pressed into the aluminium block for bores, this feature allows for a full water circulation and completes our single layer Orgone accumulator. It also makes it less leaky and more conducive to conversion to a Joe cell system. Remember Orgone loves water.

The above gives me a reason why some motors start first shot and others may take weeks to kick in. Two other effects hinder or help the above. The first is, that Orgone seems to " like " to travel in aluminium or it finds aluminium more difficult to penetrate. So it would have a tendency on leaving our aluminium pipe to either prefer the aluminium block or, once it was inside the block, it may have a greater difficulty in " leaking " out. I would be the first to admit that I do not understand this effect, but it is definitely there. As more information comes to hand, I will update these notes. The second is the easier conversion of V8 motors. As our blanking entry plug is located in the vee formed by the two banks of 4 cylinder's, the Orgone distribution from the cell is ideal, ie. it is a central entry, nearly equidistant and close to all cylinders. Another important feature is that the entry point it is on the cold side of the motor, ie. the exhaust system is on the " other side " of the cylinders. This also give a cross flow motor an advantage.

So what is to be made from the above? I would suggest, like Joe, to start on an easy conversion until you build up your own confidence and hence the " Y " factor. Either go and see a converted car so you can believe, or convert an old Rover or Leyland V8 as a group effort. I cannot see why the different club's and interest groups cannot pool together and purchase an old wreck.

If you insist in converting your cast iron whatever, be prepared to wait for the molecular changes that seems to occur to cast iron, siamesed bore and manifold type motors. As Joe stated, this may take 3

or 4 weeks. I have personally installed cells that are stage 3 and left them " running " on the car. The car was driven normally on petrol or gas, until the idle or engine operation noticeably changed. This was the indicator that the " molecular " changes have occurred and the car was ready. What you also may want to try is to replace the normal radiator water with charged stage 3 water. This should speed up the acclimatisation process. As most modern motors run some form of inhibitors and anti freeze additives in the water, you will have to consider the consequences of playing around with this mixture. The down side of dumping the additives may be increased corrosion on alloy component's, ie. head, manifold, water pump etc. Due to the tendency of the motor to run much cooler on the Joe cell, I would recommend that you leave the Glycol in the water. Obviously you throw all new car warranties out the window, the moment that you add the Joe cell and its related conversions to you car.

A2. Fuel injection cars. The simplest way to treat these cars is to perform a full conversion to gas. In this way you have a dual fuel system, ie. Joe cell or gas. Plus you pick up the advantages of a longer life span for your engine as per Chapter 10.

So really all that I can suggest in this section is that if the car will not start at ALL and all other Sections been covered, you should give the conversion a maximum of 4 weeks for the cell to take over. If the cell does not kick in that period, the chances are indeed slim that it will ever work. All cars including fork lifts, dragsters and diesel motors that Joe converted eventually ran! If your car will not, consult your favourite " expert ", or drop me a line only as a last resort when you have exhausted all other avenues. Please be reasonable, realise that I am only one person, I have a life and family, I do not get paid for my time by you or the hundreds of others requiring help. Irrespective, I will do my best to help.

A3. Car runs erratically. This could be caused by many things.

- * The cell is marginal. Check that it is still at stage 3.
- * The cell has become magnetised. See previous section.
- * The day is hot, or the cell is too hot. Feel the cell!
- * The day is wet or humid. See section 6.
- * You or your passengers or animals are interacting with a marginal cell. See section 7.
- * Your ignition timing is not optimised. Adjust!
- * Your water has gone " off ", or you water level has gone down. Rectify!
- * Your cell cylinders are polluted. Dismantle and clean.
- * You are in a high DOR area with a marginal cell. Hopefully you can drive out of to before the cell dies.

* You are in a strip of low or reversed Orgone. As above.

* Sun or planetary activity is detrimental to cell output. Change over to " normal " fuel and wait for more favourable times.

A4. The car runs. Great! Good for you. But, please remember that it will not run all the time and will stop unexpectedly and with no warning signs, so always have a dual fuel system set up and ready to " kick in ". It is highly embarrassing being thousands of kilometres from home and asking the local mechanic to fix your Joe cell conversion! You should see an interesting look on his face.

The performance of your car will be determined on the reserve of Orgone density you have on demand. A leaky or under capacity cell will not give you maximum power. A good cell will give you at least the same and usually a greater power range with a sweeter running and more tractable motor.

6. Geographic location.

As mentioned, Orgone is not a constant, or even density cover on this planet. Some of the resulting problems are;

* The density varies seasonally.

* The density varies with the time of day.

* The density varies with planetary motions.

* The density varies with the sun's cycle.

* The density varies with altitude.

* The density varies with geographic location.

* The density varies with the " users " of the Orgone energy eg. a nearby car.

* The density varies with the weather.

* The density varies with the introduction of pollutants.

* the density varies with the earth's and cosmic magnetism.

As you can see from the above, it is a wonder that we can use it at all, with our crude knowledge and even cruder cell. The main solution is to have a cell that is not too leaky. This means that the cell is always over producing thus giving you some valuable time to drive out of the unfavourable locality. This is why I have suggested that you should have a dual fuel system and at no stage rely on the cell

alone. It is one thing to have it fail on your garage bench and a completely different thing to have it fail in the outback.

Orgone has a very big disliking for any form of man made electromagnetic radiation. So any large high voltage power line, transmitters, airport radar, military installations or radio active sources will set up a reaction with the Orgone to create DOR. This may be so severe, that as Joe say's, " the water has gone bad ". Unfortunately, as you are probably already anticipating what I am going to write, this requires a clean of the cylinders and insulators , fresh water, etc.

7. The Y factor.

or the rational, proof only, and died in the wool scientific types, you are going to hate this one! Basically as Reich discovered, the Y factor simply stands for You. Yes, unfortunately when you get to the grey areas where known science merges into the unknown, you enter areas that will stretch your belief system if you so allow it. I could have very easily left the so called non scientific mumbo jumbo out of this book and so given myself " scientific credibility " whatever that means. Luckily, as I am self funded and do not live on grants by writing " selected " papers, no multi national can conveniently shut me up or rephrase the above to suit their needs.

In actuality, it is immaterial if you believe or do not believe in the Y factor, either way it exists and you really should consider the concept of all creation being intimately linked permanently and instantly.

The Y factor will make your Joe cell either not seed at all or not breed or breed poorly or behave in an intermittent fashion depending on the living energies around it at any one time. This is not a fable coming out of my demented brain, but an observed fact, recorded from all over the world for countless centuries.

The best procedure with the cell, or for that matter any endeavour is to treat it with an open mind. You do not have to believe that it will work, but similarly you should not doubt that it can work. Do not analyse too much or apply blinkers to you thinking process by presuming that you have learned all that there is to know and this cell could never work. Unless you are the Almighty himself, you will learn new things every day for the rest of your . I have talked to many, many intelligent individuals that simply refuse to believe that a car can run on what they see as nothing, nor how this nothing can get into a " solid metal " engine through no openings and produce no measurable pollution. But these same individuals who consider themselves sane, with reservations for my sanity, are quite happy to spend large sums of money or follow some outlandish new age fad in medicine or self healing techniques with even less proof or science!

CLOSING COMMENT.

My dear patient reader. At no stage have I said that the Joe cell is similar to making a bread toaster. As you are dealing with a little known mass less life force, you are behind the 8 ball right from the start, your battle is uphill and lonely, with jeering and laughing " experts " on both sides waiting for you to fall. Similarly at no stage have I said that all people can convert all cars. Likewise, once you

have converted your chosen car, there is no guarantee in how long it will run, before the breeding stops and or the seed dies.

With the right mind set, all the above are minor problems and enjoyable challenges. But if you approach this conversion, in a rush, not really believing in your heart that it can work, or with the intention of making lots of quick money, the Y factor is going to bite you! Don't even start, you are wasting your time and money. Think about it! If it was so easy and if all and sundry could exploit the life force, why is it not in mass production out in the real world? The answer is simple. It is exactly the mind set of these type of individuals that prevents them from utilising mother nature's secrets.

My aim has been to show you a method of cell construction that works for me. Obviously, there are many different ways of encourage the life force to enter an accumulator, storing it, increasing the stored density and finally utilising the force as you make it work on its release. I have read all materials available to me relating to the life force and its utilisation. Over 6 years, I have compiled, analysed and experimented with the combinations that showed the greatest potential. I am not infallible, nor do I claim I make the best cells. I only claim that I make cells that work! You are reading some of this work. As I give you this information freely, I hope that you will also distribute it freely. What you do with this knowledge is your decision. Hopefully, as a result of your efforts you will share any new knowledge or short cuts with the rest of us, so we can all grow together as a brotherhood.

Chapter 12.

Do not over analyse or overexperiment.

This will destroy the experiment and it's creative Orgonomic force.

Dr. Wilhelm Reich

When things go wrong.

well, my dear reader, you are reading this section for alternative reasons, some are;

A. You always read a book or notes from cover to cover before you start a construction project. Great, good idea, read on.

B. You are an armchair scientist and you are reading this information to see how it fits in with your own pet opinions on the subject. Good luck and I hope if you find something to contribute, you will do so freely and in brotherly love.

C. You are reading this chapter because you have made a cell by other methods and are looking for a quick fix. I would strongly recommend that you read and absorb all the previous chapters, as you may have a borderline cell and it may be better to construct a new cell.

D. You are here because you have followed exactly, all my suggestions, and your car will not run on the cell.

In the above, I am only interested in reader D.

Approach to the problem

All problems irrespective of complexity can be solved, in a methodical rational fashion. If it looks insurmountable, break it down into convenient smaller sections that you can cope with. Have this smaller section cover one topic only. Make sure that you have a working knowledge of the topic. Take your time, and have somebody else to talk with regarding your chosen solution and approach.

It is important that you change one variable at a time only! If you change variables in a haphazard method or without recording your observations, at the end of the day, you will be worse off than when you started. I would suggest that you break up your problem into the following topics.

Fault finding topics

1. The water.

1a. Cell maintenance.

2. The cell construction.

3. The charging operation.

4. Cell to car interface.

5. Car modifications.

6. Geographic location.

7. Y factor.

1. The water

The single most common problem that you will encounter is the water. As Joe remarked on many times, the "water goes bad". Not a scientific explanation but well said.

So, what are some of the problems with the water?

A. Is the water dead or polluted right from the start? If you collected, transported and stored the water personally, you should know its history. Re-read Chapter 8. If you still doubt your water try the

following. Orgone accumulates in water and as such, when you transfer the water out of the cell, you take the charge with it. Therefore, if you, or an acquaintance has a good, ie. stage 3 cell, the water can now be substituted into the suspect cell. On now powering up the suspect cell, within 1 minute you cell should be at stage 3. If the suspect cell does not come up to stage 3, the water is not at fault! The above is by far the easiest way to test a suspect cell, unfortunately you will need another cell or external help.

Note. Do not leave the charged water outside its cell for longer than 1 hour as it is not breeding.

B. Has the pH of your water changed? Simply run your pH test on the cell water. The reading should be the same. If not either the cylinders or the insulators are breaking down and reacting with the water and electrolyte. Make sure that you followed charging, insulator and cylinder material type recommendations.

C. Is the water clear? As in B., the cylinders or insulators are breaking down. Or the cell has gone into a base matter creation mode. As this topic is highly controversial and not pertinent to this subject, your only option is to completely dismantle, polish and clean the cell and or replace the insulators. Fill with fresh juvenile water. Go through charge stages as per Chapter 9.

D. Is there any residue in the sump? As in B. and C. above.

E. Are the stage 3 breeding indicators behaving the same? Read chapter 9 and make sure that the behaviour of the bubbles and meniscus are the same, especially the long term bubble retention. Again if all else fails try the voltage check.

F. Have you changed locations and the cell is now sitting in a low density Orgone strip? Make sure that the cell is at stage 3. Read Chapter 9.

G. Have you accidentally shorted out the cell or reversed polarity to it? See if it goes back to stage 3 if you apply power to it for 1 minute. If not dismantle, polish and clean all components. Fill with fresh juvenile water. Go through charge stages in Chapter 9..

H. Have you allowed the seed to die? Read Chapter 9. Go through stage 1, stage 2 and stage 3 process. The cell may go to stage 2 or even stage 3 within 3 minutes.

I. Has the cell fallen over at any stage? Try 1 minute charge and see if the cell goes to stage 3. If not, dismantle, polish and clean all components. Fill with fresh juvenile water. Go through charge stages in Chapter 9.

1a. Cell maintenance.

I have found after a cell has been in operation for about 6 months, although there is no external indications of malfunction, ie. the cell is happily breeding, it is a good idea to do the equivalent of an oil change and grease. You may find one or more of the following;

- * There is a light deposit on the cylinders particularly the outside of the 1 inch and 2 inch.
- * The cylinders may have sagged from the vibration, ie. they are not flat on the top horizontal alignment..
- * If rubber insulators are used, you will find that they have developed a set.
- * Some of the insulators particularly the inner top ones may have a light white or grey deposit on them.
- * There may be a slight suspension or colloid towards the bottom of the cell.
- * There may be slight indications of a brown sediment on top of the water.
- * The cell metal parts may have become magnetised.
- * The lower insulators for the bolt may have shrunk and could be weeping.
- * The electrical connections to the cell may be loose or corroded.
- * The compression fitting for the aluminium pipe may be loose.
- * The short piece of rubber or neoprene hose to the blanking plug may have aged.

The cure for the above are self explanatory. The only difficult one is if the cell has become magnetised. You may be able to degauss the cell or at worst you may have to have the offending cylinder replaced or heat treated. When you demagnetise your cell find a better location for it, or it will only happen again!

I do a regular 6 month service on my cells. The steps I perform are as follows; I pour out the charged water into a 5 litre glass container and put it in a cool dark area. Obviously the glass cylinder is clean and only used for your Joe cell work! Remember you have approximately 1 hour to replace the charged water back into a seeding and breeding cell. I next dismantle the cell and clean all surfaces with mild acetic acid. I find that it is not necessary to repolish the cylinders, but you may do so if it makes you feel better. I rotate any rubber insulators 180 degrees so as to use a fresh surface with no set. I lubricate my bolt and associated insulators with Vaseline and reassemble the cell. By this time the charged water has been sitting for about 1/2 hour in the glass cylinder and the majority of the sediment has settled to the bottom of the glass container. I now pour the charged water back into the cell using a paper coffee filter to catch any sediment. I stop pouring the charged water into the cell, when the first drops of water with the sediments starts to leave the glass container. This water I discard or have analysed to amuse myself. I now top up the cell with fresh juvenile water and connect the cell to the power supply. Within seconds you will see a fine white cloud develop on top of the

water. This is the residue of the acetic acid that you used to clean the cell with. I remove this simply by wiping the top of the water surface with a paper towel. Within 1 minute your cell will be back at stage 3. That's it, you have just completed your 6 month service.

Note. I will repeat again in case you have forgotten, but all water, containers, funnel etc. must have only juvenile water used in the cleaning or transferring of water for the cell maintenance. It requires a very small quantity of tap water that has been "enhanced" by good old mankind to kill the cell. Don't blame me if you have to start at stage 1 again by being lazy.

2. The cell construction

Needless to say, you should have followed the cell construction Chapters to the letter. If you did not, you obviously know how to make a different type of cell, and these notes will not be 100% relevant, or you have chosen to be creative, frugal, haphazard, or slap happy at the wrong time. I repeat, you are not making a toaster! You are trying to induce the life force to work for you. You cannot capture the life force as in a cage. It will enter and exit as it sees fit. It can penetrate all materials!

If the cell was working at stage 3 and now will not work.

A1. A common problem is that the cell cylinders have moved due to rough handling, vibration, or the wrong diameter insulators. The fix is a dismantle and re alignment. Make sure that your hands are clean!

A2. Another common problem is the covering of the cylinders and insulators with various residues. This can be seen on the dismantled cell, as an easy removable film on the cylinders and insulators. In this case treat as a dead cell and dismantle, polish and clean all components after finding the cause of the problem. The usual causes are wrong welding material or flux, wrong cylinder material type, wrong insulator material type, or water problems as in section 1. above. Fill with fresh juvenile water and start at stage 1.

A3. The cell material has been magnetised by locating the cell near starter cables or other high current carrying wiring eg. Hi-Fi wiring, fog lamp or other types of ancillary lights wiring, winch wiring, etc. In this case find the magnetised component or components with your test magnet and replace or de-magnetise the affected components. A hot under bonnet location will cause similar problems. After fixing the cell relocate the cell or the offending items.

A4. The insulators or the cylinders are eaten away to some degree. You will pick this up in the discolouration of the water. If you followed my instructions this will not occur. The problem is incompatible steel or insulators with the water electrolyte combination. In any case treat the cell as dead, replace faulty components etc. as in A2

If the cell never worked at stage 3.

B1. The cylinder material type. As mentioned in Chapter 6, the material that you use is critical in your early learning stages. All 316L is not the same! Re read Chapter 6.

B2. The cell cylinder dimension is wrong. Re read Chapter 6 and Chapter 7. The cylinders must be level at the critical chamber separation area which are formed by the tops of the internal cylindrical tubes. Re check that the cylinders are level. You should see no light when measuring with a straight edge.

B3. The cylinder finish. As the top and bottom cuts are finished in a lathe, they should be absolutely smooth, ie. no file or cutting marks. Similarly there should not be any heat bands where the cylinders were cut. The surface of the rest of the cylinder does not have to be mirror smooth, but make sure that there is no longitudinal marks or scratches. If you followed Chapter 6, they will be Ok.

B4. Make sure that the welding is done as per Chapter 6. Make sure that all internal irregularities caused by the welding process are removed, without causing excessive localised hot spots.

B5. Make sure that all threaded couplings from the cell to the engine is metal to metal joints and the threads are not covered in sealants or Teflon tape etc.

B7. Make sure that the cell is air tight. If you apply your power source for a minute or two to the cell and block the outlet of the aluminium pipe with your finger only, you will feel the release of pressure on removal of your finger. Do not do this near flames and or explosive gasses! This will also check that your cell is not open circuit or shorted and that it is electrolysing.

B8. In B7 above, the most common electrical problems are the push fit of the 1/2 inch bolt into the 1 inch pipe, and the insulators between the 1 inch bolt and the lower cell exit point.

3. The charging operation

The failures can be subdivided into 3 sections;

A. Failure to get to stage 1. If you cannot get the water to electrolyse at all, you have not read Chapter 9. Even blind Freddie and his dog can do this. Hang your head in shame and take up another interest! Seriously, not many things can go wrong. If your power source is putting out about 12 Volts and if you have added the electrolyte as described, then you must have some bubble activity in the water. If still no bubbles in the water, connect a 12 Volt car globe of any type to the very ends of the leads that you are connecting to the cell. The lamp will light if your power source and your leads are Ok. Now remove the lamp and put the positive lead to the outside surface of the cell and the negative lead to the 1 inch bolt that connects to the 1 inch cylinder. If you still have no bubbles, the 1 inch bolt connection to the 1 inch tube is faulty, but highly unlikely. Re check the insulators that insulate the 1 inch bolt from the outer container. As there is now water in the cell you will not be able to do your insulation test but you should still read more than 10 Ohms resistance from the bolt to the case. Be careful of misleading readings if the cell is acting as a battery, as your Ohm measurement will be useless.

B. Failure to get to stage 2. By this I mean that the cell has not seeded and remains at the electrolysis stage. As explained, is the cell will not seed, the indication is there is no change in bubble size or surface tension. Boy oh boy, I have been here many a time myself and I suggest the following;

B1. The first and most common is the covering of the cylinders with a coating of various chemicals. In my early days, when I took the lazy way out and brazed or silver soldered my casing joints, this compound ended up all over the rest of the cell due to electrolysis. As the positive is the donor surface and the outer casing including welds, sealants etc., this fact aggravated the plating process.

B2. Another failure and resulting contamination, was the use of the wrong type of sealant on the central insulator for the sealing of the 1/2 inch bolt where it passes out through the bottom of the cell.

B3. Likewise, when I decided to press fit my outer cell components, I used an automotive silicon gasket cement on the joints. This also ended up plating the whole cell.

B4. If the water smells un-healthy or there is scum floating around, the water has gone bad. Replace with fresh water and go back to stage 1.

B5. Check that you insulators have retained the original manufactured colours. That is, if red rubber, make sure they are still red, if silicone tubing, make sure it is still clear etc. The insulators may be fine for stage 1 electrolysis, but may be very leaky to Orgone.

B6. Your working area or you may be detrimental to the seeding of the cell. See 6. and 7.

B7. You are not covering the cell overnight and or between experiments. As previously explained, we want to keep a very mild air seal on the cell. This is easily done by placing a lid on the test cell or by having a spare aluminium plug in the end of the hose where it fits onto the engine fitting. Again I must repeat, DO NOT. use worm drive clips on both ends of the rubber coupling sleeve. The rubber sleeve must act as an one way exit for any pressure in the cell. The internal cell pressure must remain very close to atmospheric during operation.

B8. You are just too impatient! It may take 4 weeks to seed the cell! Just spend a few minutes a day with it and go and do something else.

B9. You have used the wrong materials. This has already been covered. Please read 2.

B10. You have used the wrong water. Ditto. Please read 1.

B11. You are using the wrong charging method. Ditto. Please read 3.

Note. For all problems in this section due to contamination of the cell by deposits, water or materials, dismantle the cell, polish, clean and refill with juvenile water.

C. Failure to get to stage 3. This is the failure of the cell to breed. Again to repeat, this is the failure of the cell to keep increasing the initial seed density to a greater but still finite Orgone energy limit. Indicators will be a lack of long term bubble and surface tension retention and an obvious non operation or marginal operation. Usually you will get to stage 3 very soon ie. within days of stage 2. Another way of describing the failure of running at stage 3, is that the cell is leaky to such an extent, the Orgone force cannot accumulate sufficient density for our need's.

C1. The most common fault of the cells in not breeding, or insufficient breeding, is caused by marginal water, construction dimensions and materials. Please make sure that you have followed these notes to the letter. If you have modified or substituted components etc., you obviously know something that I do not know and if your cell had worked, I would love to hear from you. But as you are reading this and if you cell is not working, I suggest you follow my instructions to the letter, or try somebody else's, " how to build a Joe cell " book.

C2. Your working are or you may be detrimental to the cell's operation. Read 6. and 7.

4. Cell to car interface.

If you are looking for faults in this area, you know that you cell is at stage 3, but the engine refuses to run from the cell.

A1. Outlet pipe from cell.

A lot of different diameters and materials will work. I would suggest, like Joe that you use 20 mm. aluminium pipe. Due to electrolytic action copper will either pollute the cell, or pollute itself. The short piece of rubber or neoprene must not have any clips on the end that attaches over the blind aluminium plug. The idea is to let any pressure " burp " out, but not to let any air in. The fitting should act as a one way valve to pressure from the cell caused by the electrolytic action. The engine end of the aluminium pipe should have you Positive electrical connection secured to the pipe by means of the same short piece of hose being slipped over it. This end should have a clip to squeeze the hose and the electrical fitting to the pipe. What you are doing is providing your Positive connection at the very end of the outlet pipe. You Negative of course will go to the cars body, (we are presuming a modern car that has a Negative earth system). The pipe fitting to the top of the cell must be air tight without the use of sealants or Teflon tape etc. The compression fitting will do a good job of this. Try to twist the aluminium pipe out of the compression fitting, if tight, you will not be able to budge it. You pipe should also have some form of insulation around it to prevent contacts to the rest of the metallic parts of the car. Ideally, the cell should be similarly protected. Remember, just one short circuit and the cell is dead!

A2. Electrical connections. The Positive wire coming from the end of the aluminium pipe should go via a 5 Amp fuse to you " ignition on " wiring. By this I mean that the cell should only have the car power connected to it when the ignition is on. Some people prefer to run this wire via an off/on switch that is located in the car. When you connect your Negative to the car, it is preferable to connect it directly to the block if you earth straps from the motor or gearbox are suspect. Either way, with the ignition on, you should measure 12 Volts Positive on the cell body and 12 Volts Negative on

the central bolt fitting. If not check you wiring, fuse, any switches, etc. The most probable cause of no Voltage is a blown fuse because you have shorted the cell. Find you short, replace the fuse and make sure that the cell goes to stage 3. If not, pull the cell out clean, polish, new water etc. ie. start again. The other most common problems are the use of sealants on the compression fitting. This is easy to find and fix. If you have 12 Volts across the cell, that does not mean necessarily that you have your 1 Amp current flow. To check this, temporally disconnect the Negative end of your cell from the car body or motor and put you Amp meter in series with the central bolt and the car connection. You should read your 1 Amp current flow. If not you have some high resistance connection's or wiring or the cell is faulty. As you are reading this because you know you cell is not faulty, the problem is either you aluminium pipe connection or you wiring. Locate the problem step by step, making sure that you do not short out or apply reverse polarity to the cell.

A3. Cell design. If you have made a cell with the wrong taper to you cone, the Orgone will focus before it gets to the motor and the cell will work brilliantly on the bench, but it will not run the car. The only reason this has occurred is that you did not build a cell as described in these notes.

A4. Cell location. Check as previously explained that the cell is located in a favourable location in the car. Is it in a cool place? is it level? Is it located as far as possible from high current wiring. Is it located in a low vibration area? Not like some rocket scientist who strapped it to his engine!!! As Orgone has a vertical preference once it leaves the cell, reduce horizontal pipe runs to a minimum. A cell located in the boot, with a 4 meter run to the engine is not a great idea. Again, a non leaky cell can run 60 meters or more into a horizontal tube, but why tempt fate? As far as the cell (but not the passenger) is concerned, for you first cell temporary location, the passenger foot well, with a pipe through the bulk head and a short, (less than a meter) pipe to the plug located at the rear of the engine (non V8) works well.

Note. At this point of the trouble shooting list, you know that you cell is at stage 3 and that it is connected correctly to the car. So if things are still not working, leave this area alone! Do not undo what you know is working ie. Don't dismantle your cell or associated connections to the car, they are Ok.! Leave them alone and look for problems in the only remaining areas you have not covered, ie. Section 5, 6, and 7. Unless you keep a systematic approach to the installation and trouble shooting you will never get the cell to run the car.

5. Car modifications.

For a start, I will again state the obvious, some cars will be easier to modify than others. Or more importantly, not all persons will be able to modify all cars! So unless you are masochistic and want to make your friend's life a misery, choose an easy car! This of course may not be old faithful that is sitting in your garage. You should also have followed Chapter 10. before you read this.

You are reading this because, you KNOW that your cell is still breeding, ie. running at stage 3, your car connections are ok. and you electrical connections are ok. You have started your car on petrol and after it has warmed up, you either have turned of the electrical fuel pump, or you have turned of the fuel to or from the mechanical pump. Now as the fuel is used up in the fuel bowl or bowls the engine falters and stops, (at this stage, I am not talking about fuel injected motors). That is how I would

expect you to test the change over phase. You are really pushing your luck, if you walk up to a stone dead car, remove the fuel to the engine and start cranking! I hope you have plenty of fully charged batteries!

The car will either run, run erratically or not at all.

A1. Car shows no sign of running from the cell. By this I mean, that as soon as the motor runs out of fuel it stop. A lot of people get here, but blame the wrong components. As stated above, you are here because you know all sections up to here are working ok. This only leaves this Section and 6 and 7. So lets presume that the car is at fault as that is the present topic.

I can tell you for a fact, that a 1971 V8 Rover will start first shot and run like a dream, likewise a 1100cc Mini Minor will not even think of starting first time. Why? There is a lot of pet theories floating around but as these are my notes I will give you my theory based on logic.

Note, the following is a theory and eventually may be proven wrong. but the way I see it is, that the water and the cylinder bores in the motor act as a single layer Orgone accumulator, ie. an Organic material, (water), surrounding a non Organic cylinder, (the bore). As such an engine with a bore that is fully surrounded with water will be far superior than an engine that uses siamesed bores or casting methods, without the benefit of the totally water surrounding cylinder. Now as most aluminium blocks have metal sleeve cylinders pressed into the aluminium block for bores, this feature allows for a full water circulation and completes our single layer Orgone accumulator. It also makes it less leaky and more conducive to conversion to a Joe cell system. Remember Orgone loves water.

The above gives me a reason why some motors start first shot and others may take weeks to kick in. Two other effects hinder or help the above. The first is, that Orgone seems to " like " to travel in aluminium or it finds aluminium more difficult to penetrate. So it would have a tendency on leaving our aluminium pipe to either prefer the aluminium block or, once it was inside the block, it may have a greater difficulty in " leaking " out. I would be the first to admit that I do not understand this effect, but it is definitely there. As more information comes to hand, I will update these notes. The second is the easier conversion of V8 motors. As our blanking entry plug is located in the vee formed by the two banks of 4 cylinder's, the Orgone distribution from the cell is ideal, ie. it is a central entry, nearly equidistant and close to all cylinders. Another important feature is that the entry point it is on the cold side of the motor, ie. the exhaust system is on the " other side " of the cylinders. This also give a cross flow motor an advantage.

So what is to be made from the above? I would suggest, like Joe, to start on an easy conversion until you build up your own confidence and hence the " Y " factor. Either go and see a converted car so you can believe, or convert an old Rover or Leyland V8 as a group effort. I cannot see why the different club's and interest groups cannot pool together and purchase an old wreck.

If you insist in converting your cast iron whatever, be prepared to wait for the molecular changes that seems to occur to cast iron, siamesed bore and manifold type motors. As Joe stated, this may take 3 or 4 weeks. I have personally installed cells that are stage 3 and left them " running " on the car. The

car was driven normally on petrol or gas, until the idle or engine operation noticeably changed. This was the indicator that the " molecular " changes have occurred and the car was ready. What you also may want to try is to replace the normal radiator water with charged stage 3 water. This should speed up the acclimatisation process. As most modern motors run some form of inhibitors and anti freeze additives in the water, you will have to consider the consequences of playing around with this mixture. The down side of dumping the additives may be increased corrosion on alloy component's, ie. head, manifold, water pump etc. Due to the tendency of the motor to run much cooler on the Joe cell, I would recommend that you leave the Glycol in the water. Obviously you throw all new car warranties out the window, the moment that you add the Joe cell and its related conversions to you car.

A2. Fuel injection cars. The simplest way to treat these cars is to perform a full conversion to gas. In this way you have a dual fuel system, ie. Joe cell or gas. Plus you pick up the advantages of a longer life span for your engine as per Chapter 10.

So really all that I can suggest in this section is that if the car will not start at ALL and all other Sections been covered, you should give the conversion a maximum of 4 weeks for the cell to take over. If the cell does not kick in that period, the chances are indeed slim that it will ever work. All cars including fork lifts, dragsters and diesel motors that Joe converted eventually ran! If your car will not, consult your favourite " expert ", or drop me a line only as a last resort when you have exhausted all other avenues. Please be reasonable, realise that I am only one person, I have a life and family, I do not get paid for my time by you or the hundreds of others requiring help. Irrespective, I will do my best to help.

A3. Car runs erratically. This could be caused by many things.

- * The cell is marginal. Check that it is still at stage 3.
- * The cell has become magnetised. See previous section.
- * The day is hot, or the cell is too hot. Feel the cell!
- * The day is wet or humid. See section 6.
- * You or your passengers or animals are interacting with a marginal cell. See section 7.
- * Your ignition timing is not optimised. Adjust!
- * Your water has gone " off ", or you water level has gone down. Rectify!
- * Your cell cylinders are polluted. Dismantle and clean.
- * You are in a high DOR area with a marginal cell. Hopefully you can drive out of to before the cell dies.

* You are in a strip of low or reversed Orgone. As above.

* Sun or planetary activity is detrimental to cell output. Change over to " normal " fuel and wait for more favourable times.

A4. The car runs. Great! Good for you. But, please remember that it will not run all the time and will stop unexpectedly and with no warning signs, so always have a dual fuel system set up and ready to " kick in ". It is highly embarrassing being thousands of kilometres from home and asking the local mechanic to fix your Joe cell conversion! You should see an interesting look on his face.

The performance of your car will be determined on the reserve of Orgone density you have on demand. A leaky or under capacity cell will not give you maximum power. A good cell will give you at least the same and usually a greater power range with a sweeter running and more tractable motor.

6. Geographic location.

As mentioned, Orgone is not a constant, or even density cover on this planet. Some of the resulting problems are;

* The density varies seasonally.

* The density varies with the time of day.

* The density varies with planetary motions.

* The density varies with the sun's cycle.

* The density varies with altitude.

* The density varies with geographic location.

* The density varies with the " users " of the Orgone energy eg. a nearby car.

* The density varies with the weather.

* The density varies with the introduction of pollutants.

* the density varies with the earth's and cosmic magnetism.

As you can see from the above, it is a wonder that we can use it at all, with our crude knowledge and even cruder cell. The main solution is to have a cell that is not too leaky. This means that the cell is always over producing thus giving you some valuable time to drive out of the unfavourable locality.

This is why I have suggested that you should have a dual fuel system and at no stage rely on the cell alone. It is one thing to have it fail on your garage bench and a completely different thing to have it fail in the outback.

Orgone has a very big disliking for any form of man made electromagnetic radiation. So any large high voltage power line, transmitters, airport radar, military installations or radio active sources will set up a reaction with the Orgone to create DOR. This may be so severe, that as Joe say's, " the water has gone bad ". Unfortunately, as you are probably already anticipating what I am going to write, this requires a clean of the cylinders and insulators , fresh water, etc.

7. The Y factor.

For the rational, proof only, and died in the wool scientific types, you are going to hate this one! Basically as Reich discovered, the Y factor simply stands for You. Yes, unfortunately when you get to the grey areas where known science merges into the unknown, you enter areas that will stretch your belief system if you so allow it. I could have very easily left the so called non scientific mumbo jumbo out of this book and so given myself " scientific credibility " whatever that means. Luckily, as I am self funded and do not live on grants by writing " selected " papers, no multi national can conveniently shut me up or rephrase the above to suit their needs.

In actuality, it is immaterial if you believe or do not believe in the Y factor, either way it exists and you really should consider the concept of all creation being intimately linked permanently and instantly.

The Y factor will make your Joe cell either not seed at all or not breed or breed poorly or behave in an intermittent fashion depending on the living energies around it at any one time. This is not a fable coming out of my demented brain, but an observed fact, recorded from all over the world for countless centuries.

The best procedure with the cell, or for that matter any endeavour is to treat it with an open mind. You do not have to believe that it will work, but similarly you should not doubt that it can work. Do not analyse too much or apply blinkers to you thinking process by presuming that you have learned all that there is to know and this cell could never work. Unless you are the Almighty himself, you will learn new things every day for the rest of your . I have talked to many, many intelligent individuals that simply refuse to believe that a car can run on what they see as nothing, nor how this nothing can get into a " solid metal " engine through no openings and produce no measurable pollution. But these same individuals who consider themselves sane, with reservations for my sanity, are quite happy to spend large sums of money or follow some outlandish new age fad in medicine or self healing techniques with even less proof or science!

CLOSING COMMENT.

My dear patient reader. At no stage have I said that the Joe cell is similar to making a bread toaster. As you are dealing with a little known mass less life force, you are behind the 8 ball right from the start, your battle is uphill and lonely, with jeering and laughing " experts " on both sides waiting for

you to fall. Similarly at no stage have I said that all people can convert all cars. Likewise, once you have converted your chosen car, there is no guarantee in how long it will run, before the breeding stops and or the seed dies.

With the right mind set, all the above are minor problems and enjoyable challenges. But if you approach this conversion, in a rush, not really believing in your heart that it can work, or with the intention of making lots of quick money, the Y factor is going to bite you! Don't even start, you are wasting your time and money. Think about it! If it was so easy and if all and sundry could exploit the life force, why is it not in mass production out in the real world? The answer is simple. It is exactly the mind set of these type of individuals that prevents them from utilising mother nature's secrets.

My aim has been to show you a method of cell construction that works for me. Obviously, there are many different ways of encourage the life force to enter an accumulator, storing it, increasing the stored density and finally utilising the force as you make it work on its release. I have read all materials available to me relating to the life force and its utilisation. Over 6 years, I have compiled, analysed and experimented with the combinations that showed the greatest potential. I am not infallible, nor do I claim I make the best cells. I only claim that I make cells that work! You are reading some of this work. As I give you this information freely, I hope that you will also distribute it freely. What you do with this knowledge is your decision. Hopefully, as a result of your efforts you will share any new knowledge or short cuts with the rest of us, so we can all grow together as a brotherhood.

GLOSSARY

Acid A substance which releases hydrogen ions when it is added to water. The hydrogen ions is solvated ie. a water molecule adds on to it, to give the oxonium ion.

Accumulator In our case a rechargeable Ozone concentrating container

Alkali A base which is soluble in water. They are usually metal hydroxides eg. sodium hydroxide, but ammonia solution is also an alkali.

Alloy Is a mixture which is made up of two or more metals or more metals or which contains metals and non-metals.

Aluminium The most abundant metal in the earth's crust, (approximately 8% by mass). It is obtained by electrolysis of Bauxite

Ampere This is the unit of electric current. It measures the rate of flow of charge. $1 \text{ Amp} = 1 \text{ coulomb/second}$.

Anion A negatively charged ion.

Anode When a solution undergoes electrolysis the electrode with the Positive potential is called the anode. In the Joe cell, it is the outer casing.

Atom The smallest indivisible particle of an element that can exist.

Battery A device which converts chemical energy into electrical energy.

Brass Is an alloy of copper and zinc.

Bronze The combination of >90% copper and <10% tin.

Capillarity The tendency of the water in a Joe cell to move up the sides of the cylinders depending on the relative attraction of the water molecules to each other and to the cylinder walls.

Cathode The Negatively charged pole in a battery or electrolytic cell.

Cation A positively charged ion.

Cell Defined in our case as an accumulator of Orgone energy.

Conductor an electrical conductor is a substance which allow an electric current to flow through it.

Current Electric current is the movement of electrons through a conductor. It is measured in Amperes.

DC Direct Current. The type of electrical current produced form a simple cell or battery.

Distilled water Tap water and rain water are not pure. They contain salts and dissolved gases. Water is often distilled to increase purity. Most of the salts are left behind but the water may still contain dissolved gases. The presence of carbon dioxide reduces the pH of the water considerably.

Electrode An electrode is a conductor which dips into an electrolyte and allows the current (electrons) to flow to and from the electrolyte.

Electrolyte An electrolyte is a solution which contains ions.

Electrolysis When a direct current is passed through a liquid which contains ions(an electrolyte), chemical changes occur at the two electrodes.

Element A pure substance which cannot be broken down into anything simpler by chemical means.

Fuel A fuel is a substance that releases heat energy when treated in a certain way. In most fuels, the energy is released by combustion. So strictly speaking, when the car is running on the Joe cell, it is not using any fuel.

Hydrogen A gaseous diatomic element. The atom consists of one proton and one electron.

Insulator. A substance which in our case is a poor conductor of both electricity and Orgone.

Ions A species which possesses an electrical charge. When an atom gains or loses an electron it becomes an ion.

Ionisation When an atom loses or gain electrons it becomes an ion. This gain or loss is termed ionisation.

Iron The most widely used metallic element. One of the main problems with iron is that it rusts.

Leaky The inability of our cell to retain the Orgone charge over a period of time.

Litmus This is extracted from lichen and used as an acid-base indicator.

Mass This is how much material a substance possesses. It is usually measured in grams or kilograms.

Meniscus The curved upper surface of the water in the Joe cell, caused by capillarity action.

Molecule A molecule is defined as the smallest particle of an element or compound which exists independently.

Nucleus This is the part of an atom where the mass is concentrated. It contains protons and neutrons.

Neutrons This is one of the particles which are found in the nucleus of all atoms except hydrogen. It has approximately the same mass as the proton but no charge.

Nitrogen It is an unreactive diatomic gas which forms about 78% of the atmosphere.

Orgone The cosmic life force. see section on Orgone in book.

Oxonium ion The loss of an electron from a hydrogen atom leads to the formation of a hydrogen ion. This is a proton.

Oxygen A gaseous non metallic element. It makes 21% of the atmosphere.

Petrol A mixture of hydrocarbons which is used as a fuel.

pH pH scale is a measure of the acidity or alkalinity of a solution. The lower the value, the more acidic is the solution. ie. the larger the concentration of oxonium ions there are within it. A neutral solution, where the concentration of oxonium and hydroxide ions are equal, has a pH of 7.

Example, Strong acid = 0, weak acid =4, water = 7, ammonia solution = 10, strong alkali = 14.

Pipette A piece of glassware used for measuring and transferring a volume of liquid.

Polymer Polymers are large molecules in which group of atoms are repeated.

Proton A positively charged subatomic particle found in the nucleus of the atom.

Rubber A natural polymer. It is a hydrocarbon. rubber is a good insulator.

Seeding The initial capture of the Orgone force in our cell.

Steel Is an alloy which contains iron as the main constituent.

Sump The lower 1 inch area under the cylinders in a Joe cell.

Suspension When a solid is added to a liquid and the solid neither dissolves in the liquid nor sinks to the bottom, the mixture is referred to as a suspension because the solid is suspended in the liquid.

Vinegar A solution which is made by the action of bacteria on wine or cider. It contains about 4% ethanoic acid. It is used widely in the food industry for preserving foods.

Water Water is an oxide of hydrogen. It is one of the most common compounds on the earth. it does not conduct electricity in its pure state although it can be electrolysed if small amounts of acid or alkali are added. the products are hydrogen and oxygen. The water which we drink is never pure.

Bibliography.

Books.

Besant, Annie, et al, " Occult Chemistry", London, Theosophical Pub. House, 1919.

Blavatsky, H.P. " The Secret Doctrine ", Theosophical Pub. House, Adyar, India.

Coats, Callum, " Living Energies ", ISBN 0 46551 97 9.

Coats, Callum, " The Water Wizard " ISBN 1 185860 049 9.

Cater, Joseph H. " The Awesome Life Force ", Cadake Industries, Winter Haven, Fl. U.S.A., 1984.

Davis, K.S. et al " Water _ The mirror of science ", Heinemann Educ., London, 1964.

DeMeo, James, " The Orgone Accumulator Handbook " ,1989.

Part available at,[Part available at,](#)

Greenfield, Jerome, " WILHELM REICH vs. THE U.S.A. ", New York: W.W. Norton & Company, Inc., 1974.

Hall, Alan, " Water, Electricity and Health " ISBN 1 869 890 94 9

Hartmann, Franz, " An adventure Among The Rosicrucians ", Boston, Occult Pub. Co. 1887.

Hilton, Barry, " How to run Your Car on Zero point Energy ". Available from NuTech 2000, 1998.

Kokaly, Aloys : " The Production of Noble Water ", Implosion.

Kronberger, Hans, et al, " On the Track of Waters Secret " ISBN 3 901626 03 4

Reich, Ilse Ollendorff, " Wilhelm Reich: A Personal Biography ", St. Martin's Press: New York, 1969.

Reich, Peter, " A Book of Dreams ", Harper & Row: New York, 1973.

Reich, Wilhelm, " THE BION EXPERIMENTS, On the Origin of Life ", Farrar, Straus & Giroux, 1979

Reich, Wilhelm, " THE CANCER BIOPATHY ", The Discovery of the Orgone ,Volume Two, Farrar, Straus & Giroux. 1973

Reich, Wilhelm, " Contact With Space, Oranur ", Second Report, 1951-56, by Wilhelm Reich, Core Pilot Press, 1957

Reich, Wilhelm, " COSMIC SUPERIMPOSITION ", Farrar, Straus & Giroux, 1973

Reich, Wilhelm, " Character Analysis ", The Noonday Press: New York, 1961.

Reich, Wilhelm, " EARLY WRITINGS ", Volume One (1920-25), Farrar, Straus & Giroux, 1975

Reich, Wilhelm, " EINSTEIN AFFAIR ", History of the Discovery of the Life Energy, Documentary, Volume A-XI-E, Wilhelm Reich, Biographical Material,

Orgone Institute Press, 1953

Reich, Wilhelm, " ETHER, GOD AND DEVIL ",Farrar, Straus & Giroux, 1973

Reich, Wilhelm, Selected Writings " An Introduction to Orgonomy ", Farrar, Straus and Giroux:

New York, 1973.

Reich, Wilhelm, " THE ORANUR EXPERIMENT ", First Report (1947-1951), The Wilhelm Reich Foundation, 1951

Reich, Wilhelm, " Orgone, Reich, & Eros " by W. Edward Mann.

Published by Simon and Schuster, copyright 1973.

Reich, Wilhelm, " THE ORGONE ACCUMULATOR " its medical & scientific use., Killamarsh, Sheffield, UK: TOPY STEEL,

1989. 32 pp.

Reich, Wilhelm, " Wilhelm Reich and Orgonomy " by Ola Raknes, Ph.D. Published by Penguin Books, copyright 1970.

Russell, Dr. Walter, et al, " Atomic Suicide? ", University Of Science and Philosophy, Swannanoa, Waynesboro, Virginia, 1957.

Schiff, Michel, " The memory of Water " ISBN 0 7225 3262 8

Sharaf, Myron, " Fury On Earth ", St. Martin's Press: New York, 1983.

Wilson, Robert Anton, " The New Inquisition ", New Falcon Publications: Scottsdale, AZ, 1991.

Wilson, Robert Anton, " Wilhelm Reich In Hell", New Falcon Publications: Phoenix, AZ, 1990.

Articles.

, ([Anderson, Rick, " Regenerating the Body's Field with Lorentz Force Generator " From Internet](#)

Brady, Mildred Edie, "The Strange Case of Wilhelm Reich." The New Republic, May 26, 1947.

DeMeo, James, Ph.D., " Pulse of the Planet " Research Report of the Orgone Biophysical Research Lab, Volume 1, Number 2, Fall 1989, El Cerrito, CA: Orgone Biophysical Research Laboratory, Inc., 1989.

DeMeo, James, Ph.D., " THE ORGONE ACCUMULATOR HANDBOOK ", El Cerrito, CA: Natural Energy Works, 1989.

DeMeo, James, "PRELIMINARY ANALYSIS OF CHANGES IN KANSAS WEATHER

COINCIDENTAL TO EXPERIMENTAL OPERATIONS WITH A REICH CLOUDBUSTER ", M. A. Thesis, University of Kansas, 1979.

DeMeo, James, "Response to Martin Gardner's Attack on Reich and Orgone Research in The Skeptical Inquirer." Pulse of the Planet, 1989, No.1.

[Article available at:](#)

Gardner, Martin, "Reich the Rainmaker: The Orgone Obsession." The Skeptical Inquirer, Fall 1988, Vol.13 No.1.

[Article available at:](#)

Hansen, George P., "CSICOP and the Skeptics: An Overview." Journal of the American Society For Psychical Research, January 1992, vol. 86.

[Article available at:](#)

[Part 2 at:](#)

[\)McCarthy, Guy, " An Analysis of the " Joe Cell " from a Biodynamic Perspective " From Internet, \(](#)

Moore, Bloomfield " What Electricity Is ",1893. From Keelynet Archives.

Schaugerger, Viktor, " Nature's Secrets Unveiled" Implosion.

Schauberger, Viktor, " The Biological Vacuum - The optimal Driving Force For Machines ", Implosion.

Schauberger, Viktor, " The mechanical Generation of Life-Force " Implosion.

Web Sites.

[Nutech Homepage. Joe cell books and videos.](#)

[Joe cell article.](#)

[Misc. Joe cell articles. \(Do a search on Joe cell\).](#)

[Wilhelm Reich Homepage.](#)

[Public Orgonomic Research Exchange \(PORE\)](#)

[Orgone Biophysical Research Lab.](#)

[Wilhelm Reich Museum.](#)

[Another Orgone Research Laboratory \(AORL\)](#)

[Orgone Bibliographies](#)

[Committee for the Scientific Investigation of Claims of the Paranormal \(CSICOP\)](#)

[A huge German / English online magazine on the works of W. Reich.](#)

From: amigo_s <amigo_s@ihug.com.au>

Subject: joe cell

Hi Geoff first i wish to congratulate on this web site, it is truly great I have been to many sites devoted to free energy but yours goes far beyond any I have seen. I have read your section on the joe cell and became furious as it is nothing but lies, joe is a major con artist who has been put up to this grand ,ground breaking awesome invention by people who wish that the search for free energy be hindered and discouraged ,the joe cell fits this category only to well. I have done comprehensive testing of the joe theory and detailed digital analyzing of his videos and found the the escort had duel fuel lines plus I have had a engine running on hydrogen and it does not burble when you reduce engine speed. I find errors in all of his presentations and can duplicate all of his

so called theories %100 anyone who claims they have got it running is a pathological liar. I have considered contacting world media and showing my proof on why the joe cell is a lie. Nobody from Nutech has seen it work nor can they provide anyone to verify that it does. Finally I wish to apologize for being so harsh but this misleading garbage must be stopped. Sir I wish also to invite you to Brisbane on the completion of my water fuel cell which I can assure you is a working prototype, will send digital photos on request.

[Web site info](#)

[joe information](#)

[Part one of the joe cell article "](#)

[Back to HV Home](#) / [Back to home page](#) /