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TESLA COIL THEORY

LINE VOLTAGE IS STEPPED UP BY THE HIGH-VOLTAGE TRANSFORMER TO A MAGNITUDE SUFFICIENT TO CHARGE THE CAPACITOR AND FORCE THE SPARK GAP TO BREAK DOWN. THIS ACTION IS REPEATED AT THE 60 HERTZ LINE FREQUENCY. EFFICIENT ENERGY TRANSFER IS ENHANCED BY CHOOSING A CAPACITOR WHOSE IMPEDANCE IS EQUAL TO THAT OF THE SECONDARY WINDING.

ESSENTIALLY, THE CAPACITOR AND TESLA COIL PRIMARY FORM ONE PAIR OF TANK CIRCUITS: WHEN THE SPARK GAP ARCS, THE MOMENTARY SHORT CIRCUIT CREATED DUMPS THE CAPACITOR'S CHARGE INTO THE COIL'S PRIMARY. THE RESULTING L-C CIRCUIT RINGS AS THE CHARGE OSCILLATES BACK AND FORTH BETWEEN THE CAPACITOR AND THE COIL. THE OSCILLATIONS DECREASE IN AMPLITUDE AS THE CHARGE IS DISSIPATED BY RESISTANCE. THE RINGING GENERATES WHAT IS REFERRED TO AS A "DAMPED WAVE". THE NEXT HALF-CYCLE OF 60-HZ RECHARGES THE CAPACITOR, STARTING THE PROCESS ANEW. A TRAIN OF HI-FREQUENCY WAVES, SPACED AT 60-HZ INTERVALS, IS THE PRODUCT.

RESONANCE MUST BE ACHIEVED TO EFFECT RINGING: THIS DEMANDS THE CAPACITOR AND PRIMARY HAVE THE SAME REACTANCE:

$X(L) = X(C)$ THE CIRCUIT RESISTANCE (CAPACITOR, COIL AND INTERMEDIATE WIRING) LIMITS THE OVERALL EFFICIENCY OF THE TANK CIRCUIT. EFFICIENCY IS RATED IN TERMS OF "QUALITY FACTOR", REPRESENTED AS 'Q':

$$Q = W(L)/R = X(C)/R$$

INCREASING RESISTANCE REDUCES Q, THEREBY REDUCING EFFICIENCY. THE EFFECT IS MINIMIZED BY WINDING THE PRIMARY WITH A FEW TURNS OF HEAVY CONDUCTOR, WELL-SPACED, OVER A LARGE RADIUS FORM - THE LARGER THE BETTER. THE CAPACITOR SIZE AND CONSTRUCTION ALSO BEAR UPON Q: THE PHYSICAL SIZE AND AREA SHOULD BE MINIMIZED. THIS, HOWEVER, WORKS AGAINST LARGE CAPACITANCE VALUES AND DICTATES THE COIL BE WOUND WITH MORE TURNS. THE GOAL, THEN, IS TO ACHIEVE A WORKABLE RANGE OF COMPONENT SPECIFICATIONS RATHER THAN TO STRIVE FOR OVERLY CLOSE TOLERANCES. COILS OFTEN ARE WOUND WITH TAPPED PRIMARIES TO FACILITATE FINE TUNING.

THE SECONDARY COIL IS SITUATED BOTH ELECTRICALLY AND PHYSICALLY WITHIN THE PRIMARY. THE SECONDARY AND ITS DISCHARGE ELECTRODE, GENERALLY A SPHERE OR TOROID, MAKE UP THE SECOND TUNED CIRCUIT. THE WINDING SUPPLIES INDUCTANCE; THE CAPACITOR IS CREATED BY THE ELECTRODE AND THE (EARTH) GROUND-PLANE. AIR IS THE DIELECTRIC. MOST TESLA COILS EMPLOY SECONDARIES OF 1/4-WAVELENGTH AT THEIR OPERATING FREQUENCIES. THIS ESTABLISHES A CONFIGURATION WITH MAXIMUM CURRENT AT ZERO VOLTAGE WITH MINIMUM CURRENT AT THE ELECTRODE. THIS SITUATION PROVES TO BE BENEFICIAL, IN THAT IT ENHANCES COUPLING WITH THE HIGH CURRENT PRIMARY, AVOIDS ARCHING BETWEEN THE PRIMARY AND SECONDARY AND GENERATES THE DESIRED HIGH VOLTAGE AT THE TOP END.

THE "OUDIN COIL IS A 1/2-WAVE VARIATION ON THE TESLA COIL. IT POSSESSES THE ESSENTIAL TESLA COIL OPERATIONAL CHARACTERISTICS, BUT IT EMPLOYS A HORIZONTALLY PLACED SECONDARY WITH DISCHARGE ELECTRODES AT BOTH ENDS AND A PRIMARY AT THE CENTER. THE OUDIN PRIMARY SOMETIMES IS MERELY A PAIR OF TAPS ON THE SECONDARY (AN AUTOTRANSFORMER). THE 1/2-

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WAVE ARRANGEMENT AFFORDS A COIL WITH MAXIMUM DISCHARGE AT EACH END AND
A VIRTUAL GROUND AT THE MIDPOINT OF THE WINDING(S).

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