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A tesla coil is one of the most fascinating electrical display devices to see in operation. A large unit can produce a continuous spark of a length exceeding the height of the coil. Electric discharges simulating lightning bolts will produce cracks of noise louder than a rifle shot. These sparks as well as being highly impressive and attention getting also can produce bizarre effects to occur in most common materials. For example, wood may explode into splinters or made to glow with an eerie reddish light from WITHIN. Insulating materials seem to be useless against this energy. Lights light without wires, sparks and corona in the form of St. Elmo's fire occurs within proximity of the device. High energy electric and magnetic fields render electronic equipment useless. Phenomena not normally associated with standard HV electricity becomes apparent in the form of many weird and bizarre effects.



GENERAL THEORY

A tesla coil is a high frequency resonant transformer. It differs from a conventional transformer in that the voltage and current relationships between primary and secondary are independent of turns ratio. A working apparatus basically consists of a secondary (LS1) and a primary (LP1). It is obvious that the primary circuit is capacitance dominant and tuning the primary circuit via taps along the primary coil does not alter the frequency by as much as one would expect. However, this relatively fine tuning of the primary circuit to the secondary is mandatory for proper operation. Force driving (untuned) the secondary coil will produce hot spots and interwinding breakdown.

INTRODUCTION TO YOUR EASY BUILD TESLA COIL

This project shows how to construct a device using a step up transformer producing 6000 volts at 20 ma from the 115 ac line. This voltage current combination can produce a painful shock and all attempts should be made to construct this device with some know how or experienced help. Safety rules should be followed at all times. The device also produces ozone - therefore, use in well ventilated area. Do not use for prolonged periods of time, 30 seconds on at any

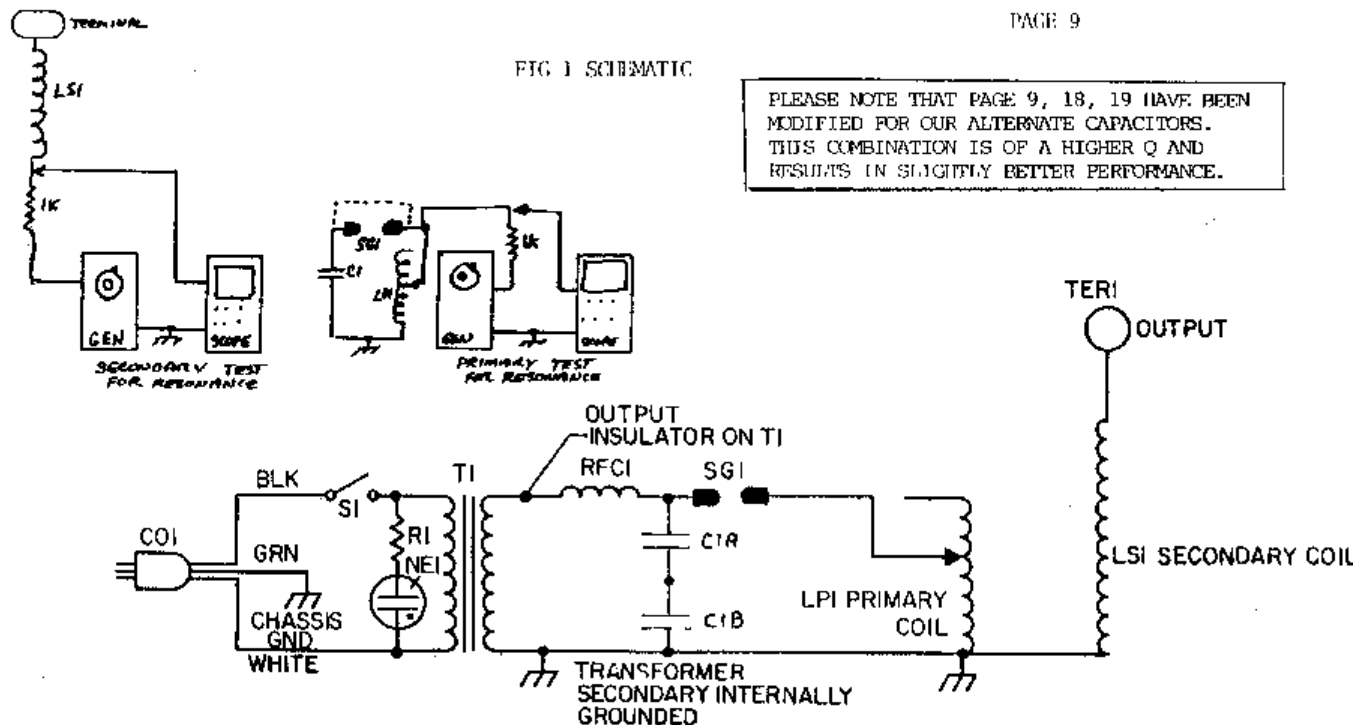
one time is ample for any demonstration. Avoid eye exposure to spark gap without ample protection such as safety glasses, shielding, etc. [Transcriber's note: This is due to emission of invisible, high energy, ultra violet rays, that in a very painful way can damage your eyes.]

The unit when constructed as shown can develop voltages up to and in excess of 250,000 volts. It will cause a discharge lamp such as a regular household fluorescent lamp to glow up to a distance of several feet from the unit. The high voltage center coil terminal can actually be touched with a piece of metal held securely in the demonstrators hand, creating quite a conversation piece.

The unit can be used for exciting all types of gas discharge tubes, x-ray tubes, plucker tubes etc. It demonstrates corona, St. Elmo's Fire and the effect of high voltage on many different types of materials. On a good dry day, with the device properly adjusted, it is possible to produce sparks 10" to 12" in length. It is designed for the experimenter who wishes to explore the effects of high frequency, high voltage energy.

CIRCUIT THEORY (Ref FIG 13-1)

The device consists of a secondary coil LS1 containing approximately 500 turns wound on a PVC form 12" long. This coil possesses an inherent resonant frequency determined by its inductance and capacity. A primary circuit consisting of a drive coil LP1 and capacitor C1 are impulse driven by a spark gap SG1. This primary circuit should also have an resonant frequency equal to that of the secondary coil for maximum performance. It is possible to force the secondary coil with less results. The output voltage of the device is dependant on the ratio of Q between these two coils.



YOUR BTC3 TESLA COIL CAN BE "RUFF" TUNED BY THE FOLLOWING STEPS: (SEE INSET)

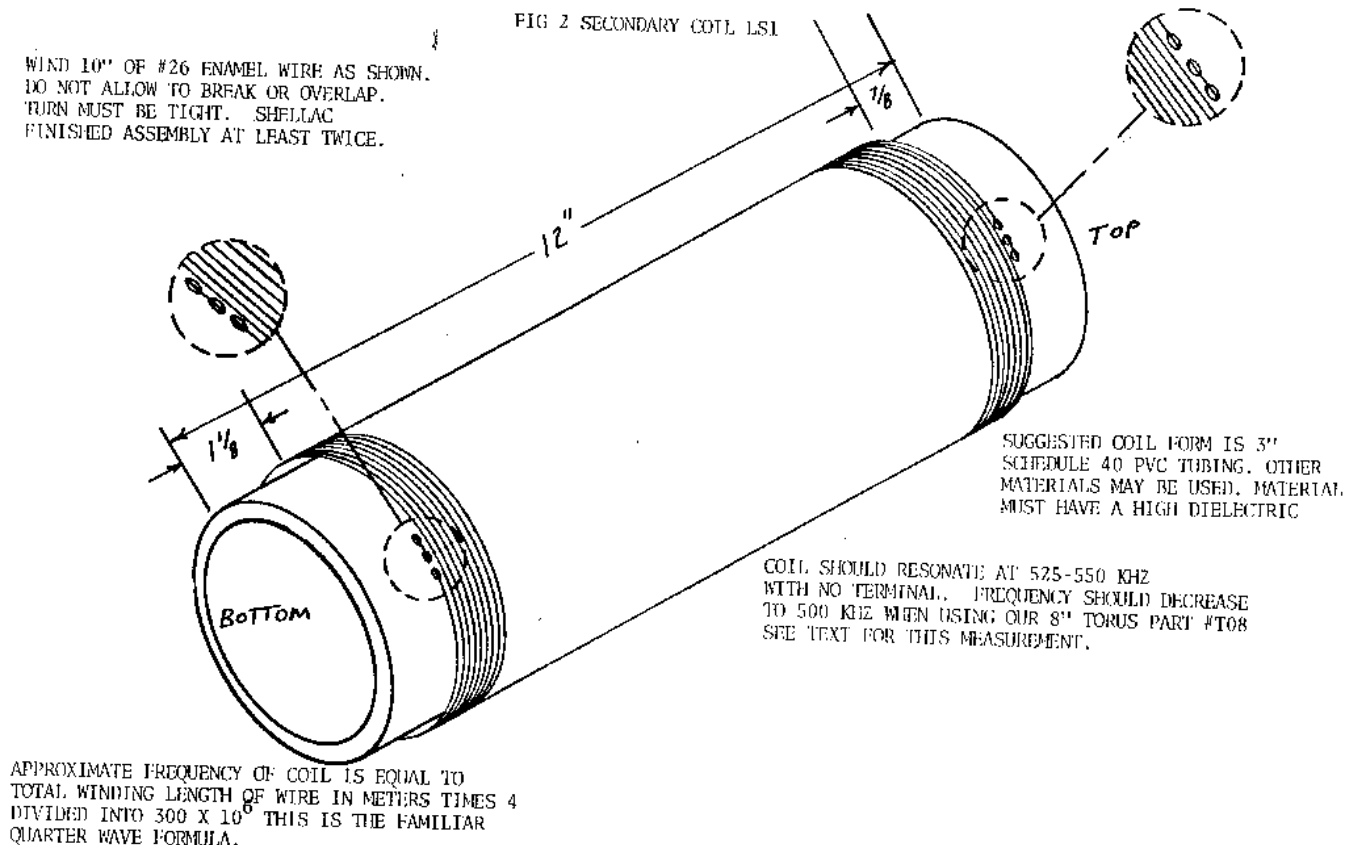
1. DISCONNECT GROUND END OF SECONDARY COIL LS1 AND INSERT A 1K RESISTOR IN SERIES WITH A VARIABLE FREQUENCY GENERATOR. CONNECT SCOPE ACROSS RESISTOR AND DETERMINE RESONANT FREQUENCY BY NOTING A SHARP DIP IN SIGNAL AMPLITUDE. RECORD THIS READING - NOTE THAT OUTPUT TERMINAL MUST BE ELECTRICALLY CONNECTED AND COIL SHOULD BE AWAY FROM CONDUCTIVE OBJECTS TO OBTAIN AN ACCURATE READING. APPROXIMATE TUNING IS AROUND 500 KHZ.
2. SHORT OUT SPARK GAP (SG1) WITH A SHORT CLIP LEAD AND DISCONNECT LEAD OF RFCL. CONNECT SCOPE AND GENERATOR COMBINATION TO TAP OF PRIMARY COIL (LP1). START AT MAXIMUM TURNS AND NOTE A SHARP RISE IN THE VOLTAGE WAVEFORM AT SOME FREQUENCY. RECORD AND REPEAT AT THE VARIOUS TAP POINTS. NOTE THE DIRECTION ROUTING OF THE TAP WIRE ITSELF AROUND THE SECONDARY WILL CAUSE CONSIDERABLE DIFFERENCE IN THE READING. IT IS SUGGESTED TO EXPERIMENT WITH THESE SETTINGS. YOU WILL NOTE THAT THIS IS A "STATIC" TUNING CONDITION AND WILL VARY SLIGHTLY WHEN IN ACTUAL OPERATION. PRIMARY RESONANT FREQUENCY SHOULD BE PRESET TO A SLIGHTLY LOWER FREQUENCY THAN THAT OF THE S1 IN STEP 1.

The primary coil has an adjustable tap that allows for fine tuning. It should be noted that it doesn't take much in the way of added capacitance to the secondary to alter its resonance pint. Even a change in the output terminal TER1 may require readjustment of the tap.

Transformer T1 supplies the necessary high voltage. It is rated at 6000 volts about 23 ma. A larger capacity transformer will produce more output but may stress the other circuit components. This voltage charges the primary storage capacitor (C1) to a voltage where it fires the spark gap (SG1) producing an impulse of current through the primary inductance (LP1) where oscillations take place. The frequency is determined by the inductance and capacity values of the primary circuit. Voltage output of the secondary coil (LS1) is usually approximately to $V2 = C1 * V1 / C2$ where $C1$ = primary storage capacity, $V1$ = the spark gap discharge voltage, and $C2$ = the secondary coil capacitance (usually relatively small). Another way of expressing this relation is that the output volts are dependent on input drive voltage times the ratio of primary "Q" to secondary "Q". There are several texts describing some of TESLA'S works and these are available through your library.

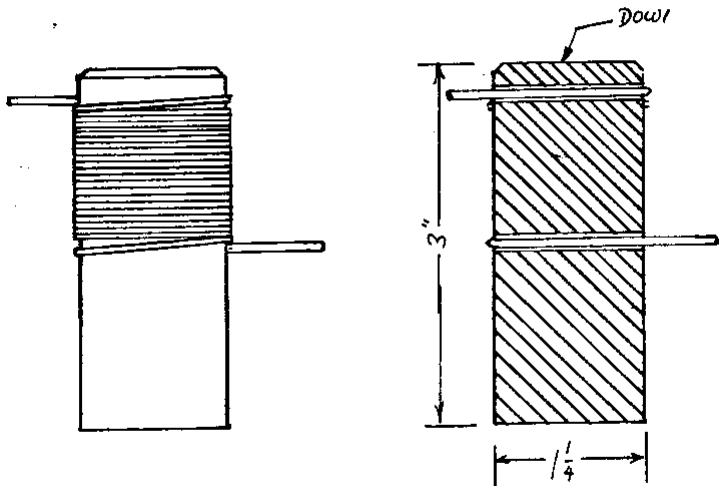
CONSTRUCTION STEPS (ref. FIG 13-2)

PLEASE NOTE THAT SUBSTITUTION OF CERTAIN PARTS MAY BE MADE BY THE BUILDER, HOWEVER, THIS MAY INCREASE OR DECREASE PERFORMANCE.



1. Wind 11" of #26 magnet wire (WR13) on coil form (CTL1). Leave 3/4" to 1" on each end. Fasten wires by threading them through small holes in coil form. Leave 12" leads. Coil form must be dry and clean. Varnish, dope or coat finished winding with paraffin wax several times to seal against moisture and hold in place. Winding must be neat and tight. Avoid kinks and overlaps as this will seriously affect coil performance.

The best way to wind the coil is with a buddy using a broom stick as a shaft and carefully dispensing the wire as needed. Keep wire taut. Winding should be approximately 50 turns per inch for 10" using less than 600 feet of wire. Final coil is secured to mounting plate (MP1) via plastic cap (CA1).



WIND 25 TURNS #18 AS SHOWN. NOTE HOLE FOR ANCHORING OF WIRES. SHELLAC FINISHED ASSEMBLY.

2. Obtain some #12 wire and form into a coil of 8 turns with a 6" diameter as shown in FIG 13-2. Hold together with tape. Fabricate 4 pieces of dry wood or plastic for SP1 1-1/4 x 3/4 x 1" for mounting and securing coil primary (LP1). Use tie wraps to secure (SP1) blocks and coil simultaneously to (MP1) mounting plate as shown.

3. To construct spark gap (see FIG 13-3) fabricate a 3" teflon block (BL1) as shown. Note angle brackets (BR1) and (BR2) for attaching (SW10) and (SW20) spark gap screws. These brackets should be tapped for 1/4-20 screws on one end. Leave enough space between bottom bracket and chassis to prevent breakdown from occurring. Note flattened shield section with attaching to screws. Note that the bottom screw has nut tightened against the bottom bracket for locking. The top screw is allowed to turn allowing for spark gap adjustment.

Attach an insulating shaft of plastic tubing by pressing on to the stud end of this screw. It may be desired to cut out a window for observing the gap. Cover hole with glass, plastic, etc., to protect your eyes from UV. For continued use, it is advised to lock SW10 via lock nut to prevent overheating.

4. (C1) capacitor is mounted via bracket as shown on the grounded end. FIG 13-4. The other end is supported via several pieces of double sided tape built up to the correct thickness for proper securing. Only one capacitor is shown. The remaining assembly is illustrated in the drawings with attention being given to proper positioning and spacing of the HV components. MP1 mounting base must be non-metallic, dimensions of metal enclosing are not critical as long as there is ample spacing. Use sheet metal screws, rivets, etc., for putting enclosure together if home fabricated. Use standard wiring and assembly techniques.

5. A convenient output terminal for the secondary can be a smooth door knob attached via a bolt thru CA2. This also looks good and gives the coil a finished look.

6. When firing up your coil, start with the spark gap set at 2 turns from "closed", and adjustment tap at maximal inductance. Note that this lead also contributes to total inductance when routed as shown. (Same direction as turns of primary coil). It should be possible with this coil to easily obtain 10 to 12 inch streamers when properly adjusted. Careful adjustment of the tap location and gap adjustment will greatly enhance performance. When operating for a prolonged period always note potential breakdown points occurring indicated by heavy corona or premature sparking. These points must be corrected or a burning tracking condition will be the result.

FIG 4 FABRICATION AIDS

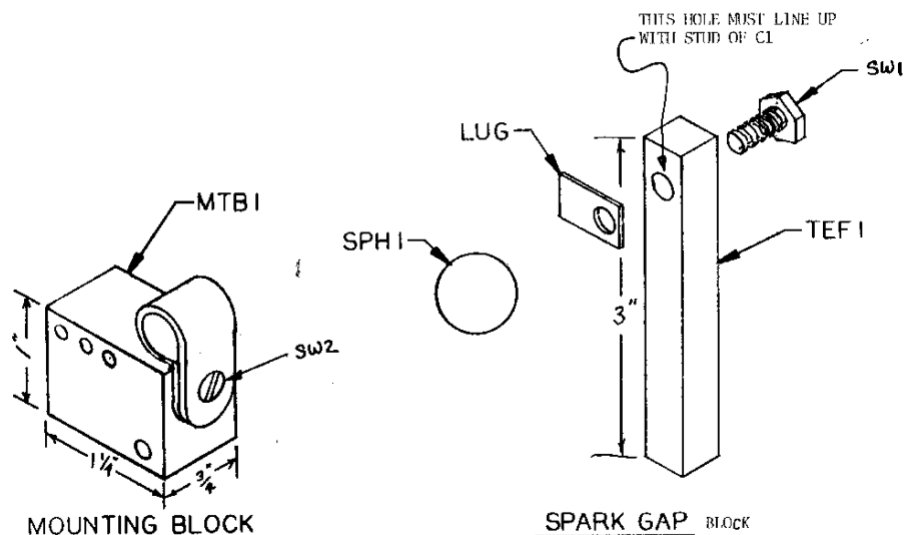
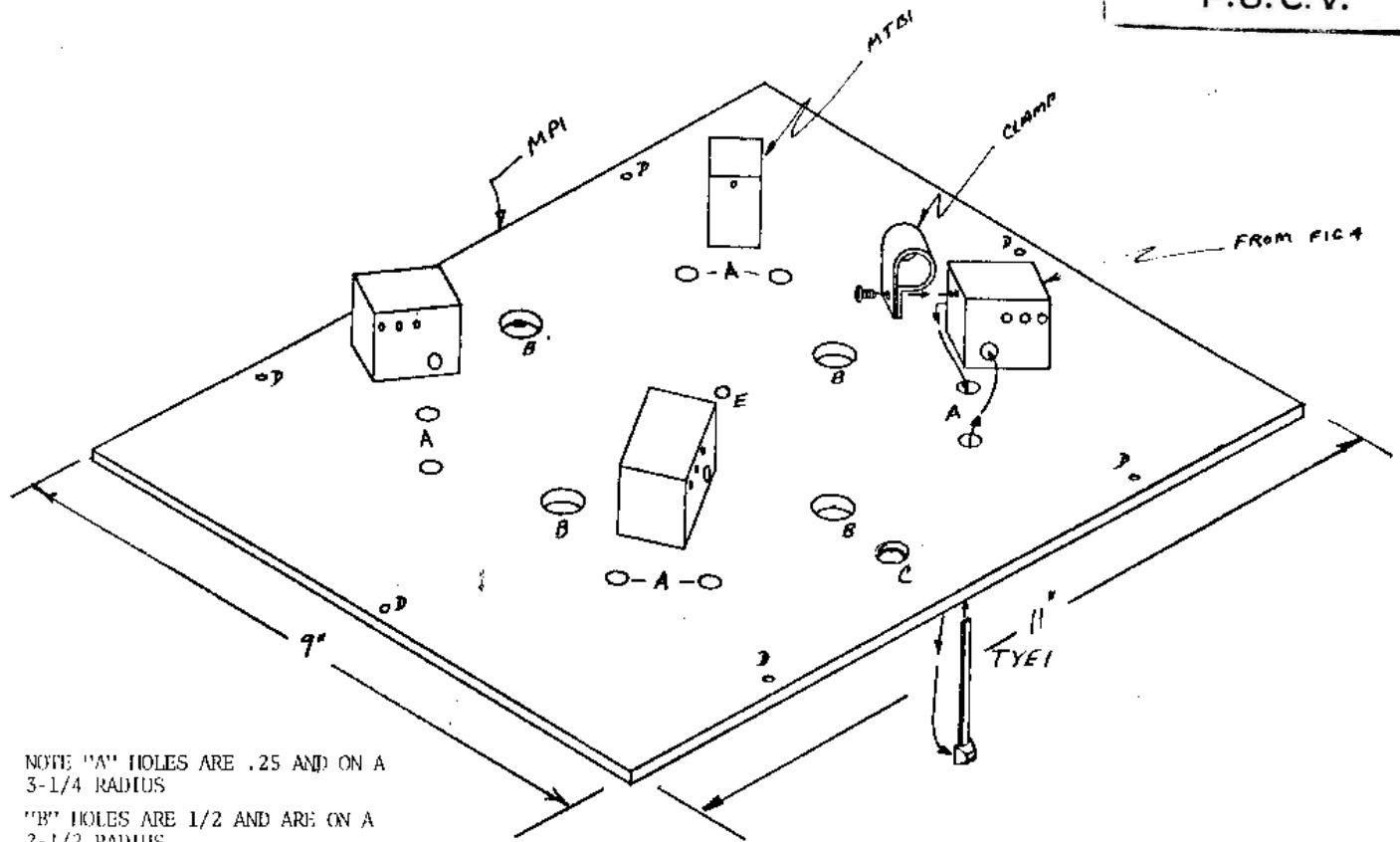


FIG 5A VIEW SHOWING MOUNTING BLOCKS



NOTE "A" HOLES ARE .25 AND ON A 3-1/4 RADIUS

"B" HOLES ARE 1/2 AND ARE ON A 2-1/2 RADIUS

"C" HOLE IS FOR GROUND RETURN OF PRIMARY

"D" HOLES ARE FOR MOUNTING TO CASE AND ARE 3/16 IN DIAMETER

"E" HOLE IS CENTER HOLE FOR GROUND RETURN OF SECONDARY AND USED FOR REFERENCE OF A&B HOLES

EXPERIMENTS WITH YOUR COIL

1. ADJUSTMENT - Suspend a grounded metallic object above the device. Start at about 3" separation and make adjustments increasing separation until the optimum spark length is obtained. (Note - grounding means connection to metal base).
2. EFFECT ON HUMAN BODY - Use caution as this may cause a reflex secondary reaction even though it is painless. Hold a metal object TIGHTLY and advance to coil terminal. Note the painless, tingling sensation. Fake out your pals by letting them think it is really painful. This demonstrates the skin or surface effect of high frequency electricity.
3. EFFECT ON INSULATORS - Place various objects on the top of the coil and note the effect of the high frequency electricity. The sparks are not stopped by glass or other usual insulators. Experiment using objects such as light bulbs, bottles, glass, etc.
4. EFFECT ON PARTIAL INSULATORS - Place wood pieces about 12" x 1" x 3" and note red streaks and other bizarre weird phenomena occurring from within the piece.
5. IONIZATION OF GASES - Obtain a fluorescent lamp and allow it to come within several feet of the device. It will glow and produce light without direct connection, clearly demonstrating the effects of the electric and magnetic fields of the gas. Note the distance from the coil that the lamp will glow. Experiment using a neon lamp in place. Obtain other lamps and note the colors, distances and other phenomena.
6. INDUCTION FIELDS - This is demonstrated by obtaining a small filament type lamp such as a flashlight bulb or similar and connecting between a large 1-1/2 to 2' diameter metal or wire loop. The lamp will now light due to energy coupled by induction. You will note that current is required to light this type of lamp and

is entirely different than the radiation field that ionizes and causes the gas lamps to glow.

7. CREATE SPECIAL EFFECTS ON PINWHEELS, COLOR FIRES, ETC. - By connecting pieces of nichrome wire as shown in sketches. Note - rotor rotates creating a ring of fire. Try different types of rotors.

8. ION MOTOR - Fab and carefully balance rotor as shown in FIG 13-5. Use piece of #16 or #18 copper buss wire. Rotor will spin at high speeds if carefully balanced demonstrating ion propulsion.

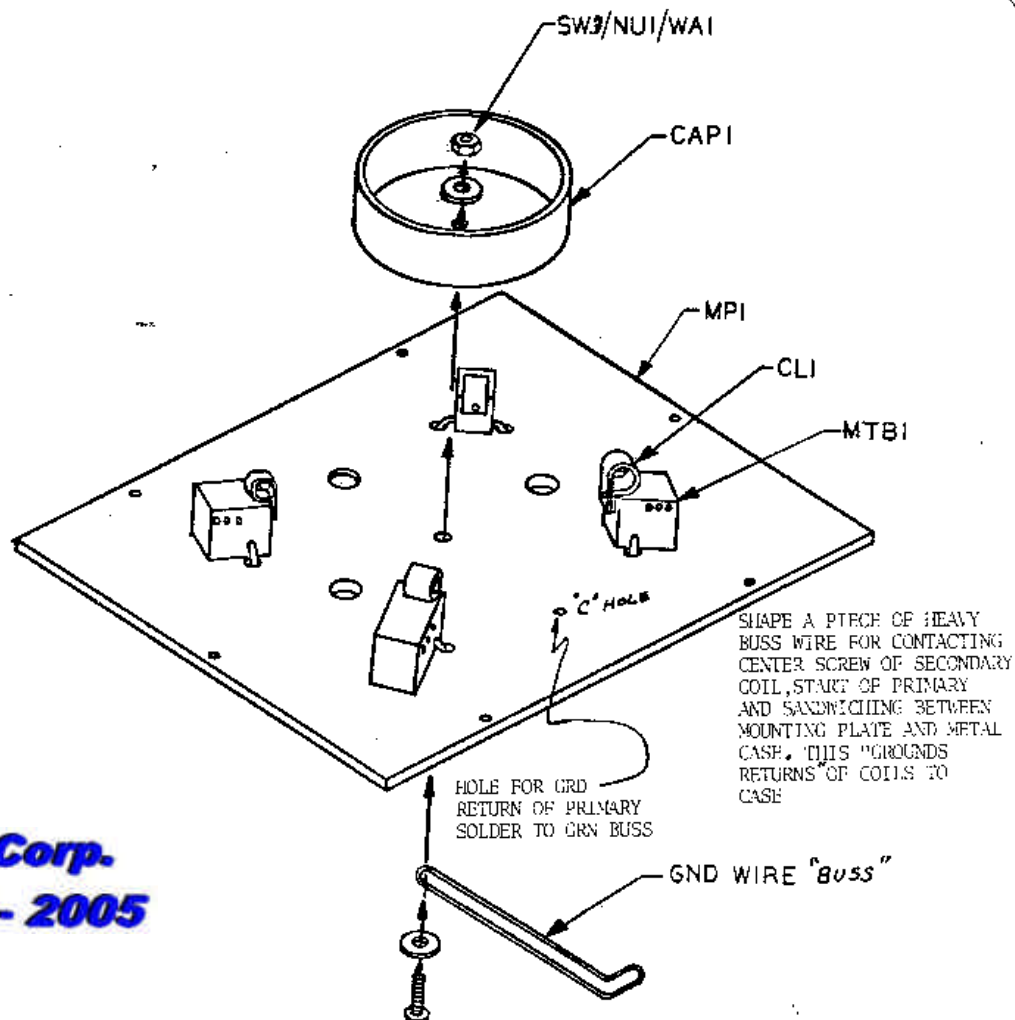
SPECIAL NOTE: - Your tesla coil is hungry for "capacitance". It is suggested to obtain a 2" to 3" aluminum funnel and place in atop of the coil. Connection can be made simply by placing on top of the output wire. Our sample lab unit at 6-1/2 turns with this setup. This does not mean yours will be identical as there are many variables that fill effect this parameter. It is important to have this top capacitance to prevent voltage breakdown along side of coil.

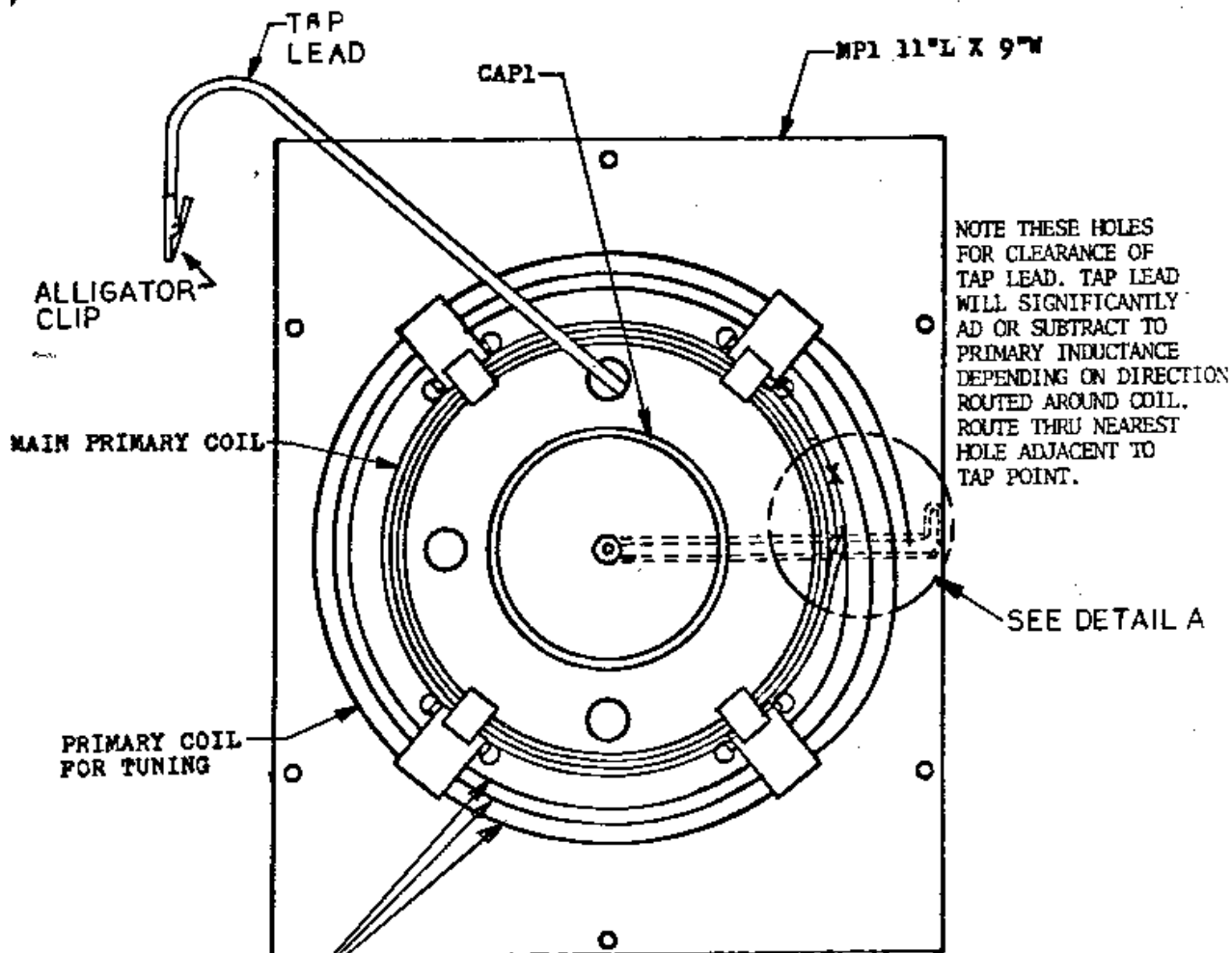
SPECIAL NOTE: - The tap wire of your coil will add or subtract up to 1/2 turn depending on direction routed around coil. Keep wire flat and away from coil to prevent damaging arcover.

SPECIAL NOTE: - Optimum output requires proper selection of the correct tap position on the primary coil. Start at 5 turns from inside and tap into wire using a metal thumb tack pushed through the insulation. Connect alligator clip to thumb tack head. When proper tap is found remove insulation & solder into place. Ref step 6 of plans. See above note.

SPECIAL NOTE: - DANGER! DANGER! Do not use this device near people with pacemakers or computerized equipment.

FIG 5B VIEW SHOWING GROUNDING CONNECTION AND SECONDARY MOUNTING CAP

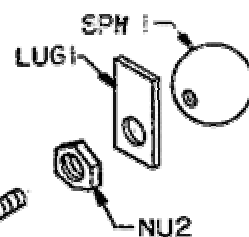




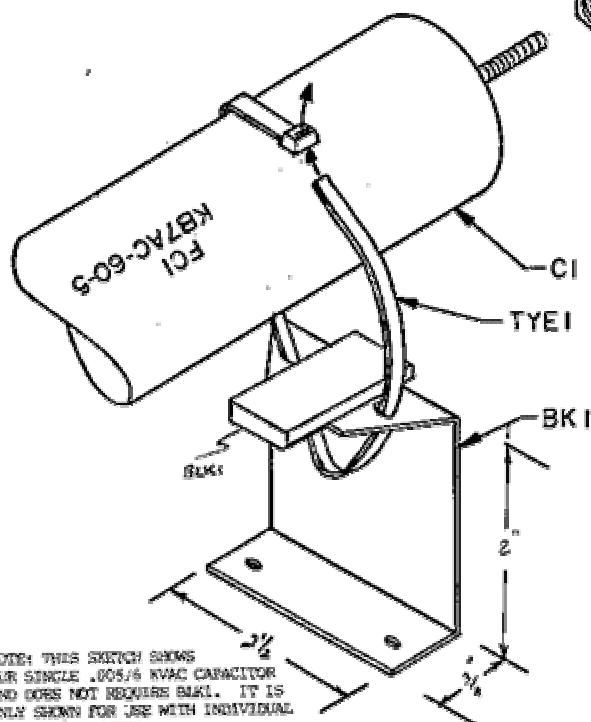
THE LAST THREE TURNS OF PRIMARY COIL ARE STIFF BARE WIRE FOR ADJUSTMENT VIA TAP SELECTION. NOTE LEAD FROM SPARK GAP WITH ALLIGATOR CLIP FOR CONNECTING.

USE A 2' LENGTH OF #12 VINYL WIRE FOR TAP LEAD USED FOR WINDING THE 6 TURN PRIMARY. PRIMARY COIL REQUIRES APPROX. 10' OF THIS WIRE. TUNING SECTION USES 6' OF #12 BARE BUSS WIRE.

FIG 6 CAPACITOR WIRING SCHEME



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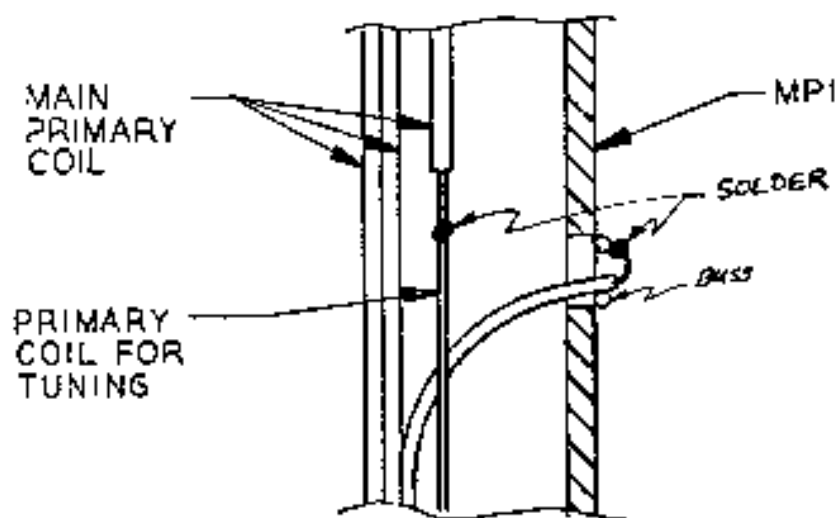
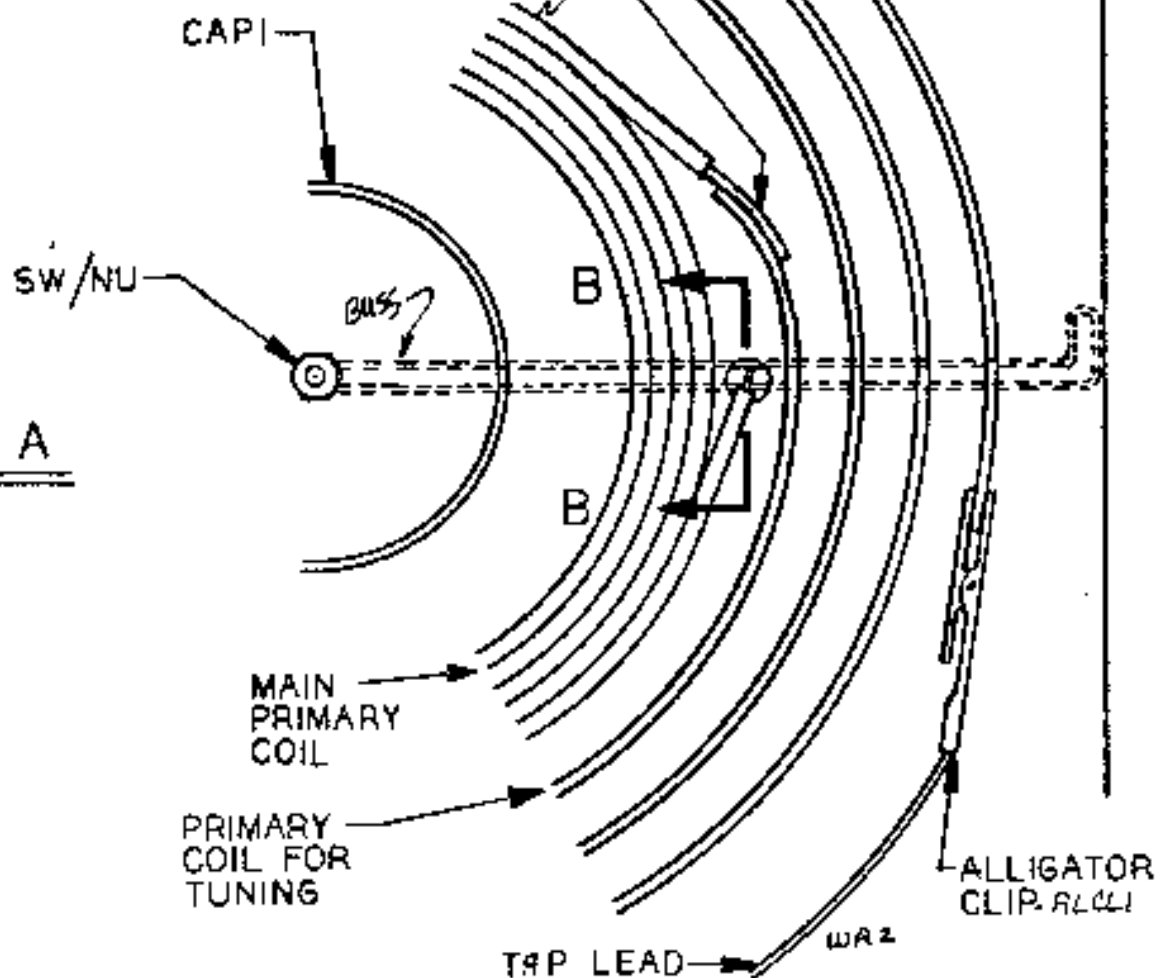


NOTE: THIS SKETCH SHOWS ONE SINGLE .005/6 KVAC CAPACITOR AND DOES NOT REQUIRE BULK. IT IS ONLY SHOWN FOR USE WITH INDIVIDUAL TWO .01 PFD UNITS.

FIG 50 DETAIL OF PRIMARY COIL AND GROUNDING SCHEME

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CONNECT MAIN
PRIMARY COIL
TO TUNING
SECTION—SOLDER



SECTION B-B

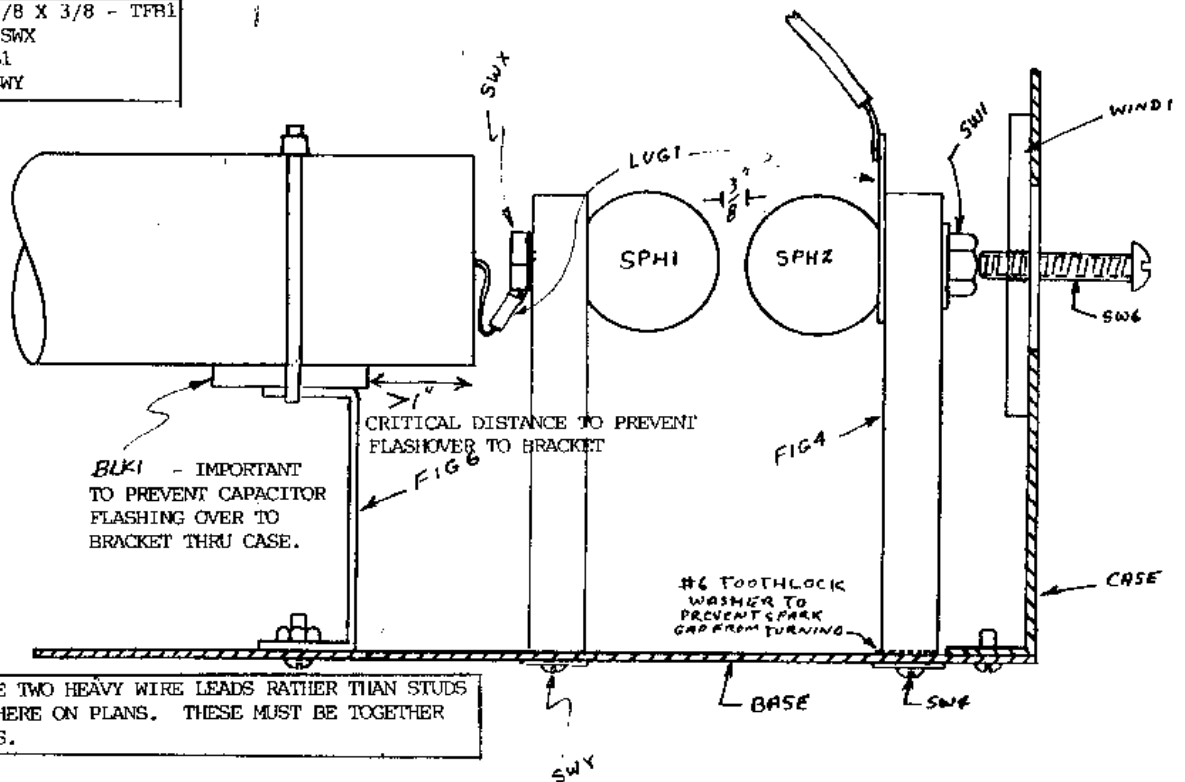
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ELECTRICA
P.U.C.V.

FIG 7 SPARK GAP ASSEMBLY

NOTE: PAGE 9,18,19 SHOW ALTERNATE ASSEMBLY USING TWO CAPACITORS DESIGNATED C1A AND C1B. THESE ARE LOW LOSS SPECIAL CAPACITORS AND REQUIRE THE FOLLOWING ADDITIONAL PARTS.

TEFLON BLOCK 3 X 3/8 X 3/8 - TFB1
1/420 X 1" BOLT - SWX
2 LARGE LUGS - LUG1
#8 SHEET METAL - SWY

"TAP LEAD FOR CONNECTION TO OUTER THREE TURNS OF PRIMARY"



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FIG 9 CASE AND BOTTOM PLATE FABRICATION

NOTE ALL BENT FLANGES ARE 1/2" UTP. NOTE LOCATION OF HOLES FOR SHEET METAL SCREWS USED FOR FASTENING.

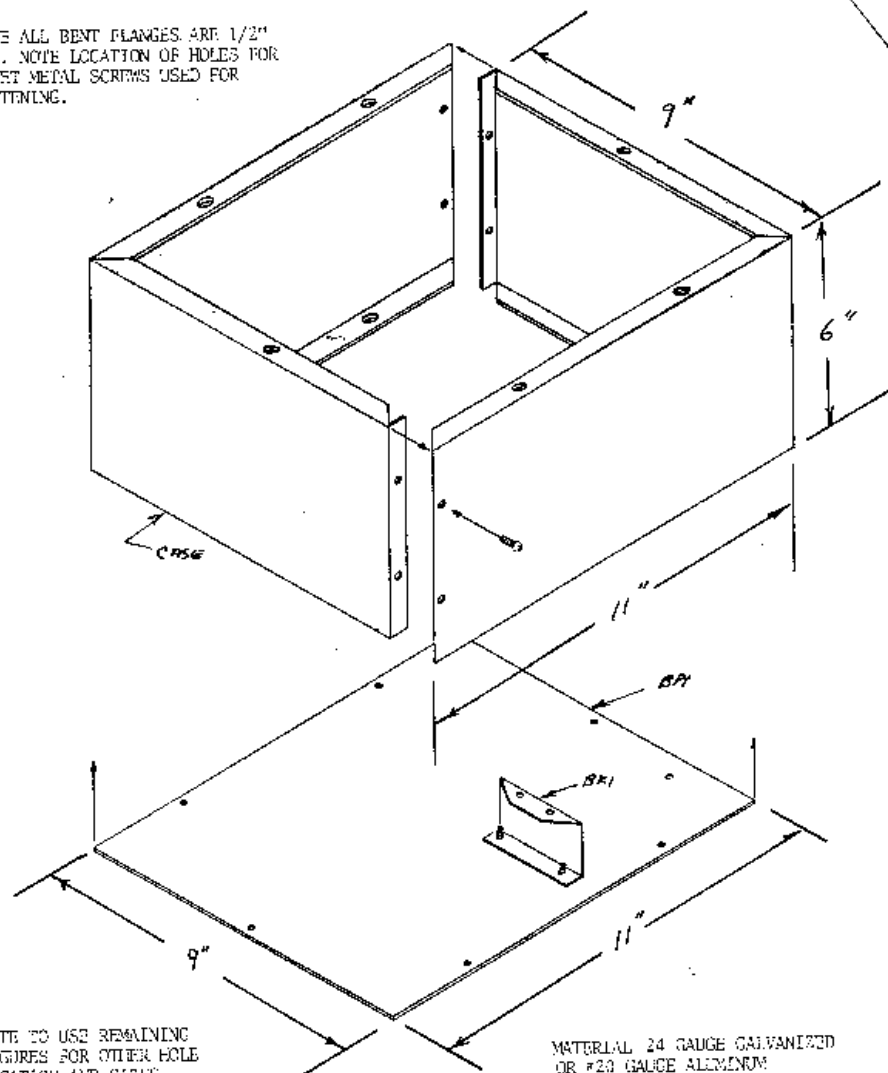
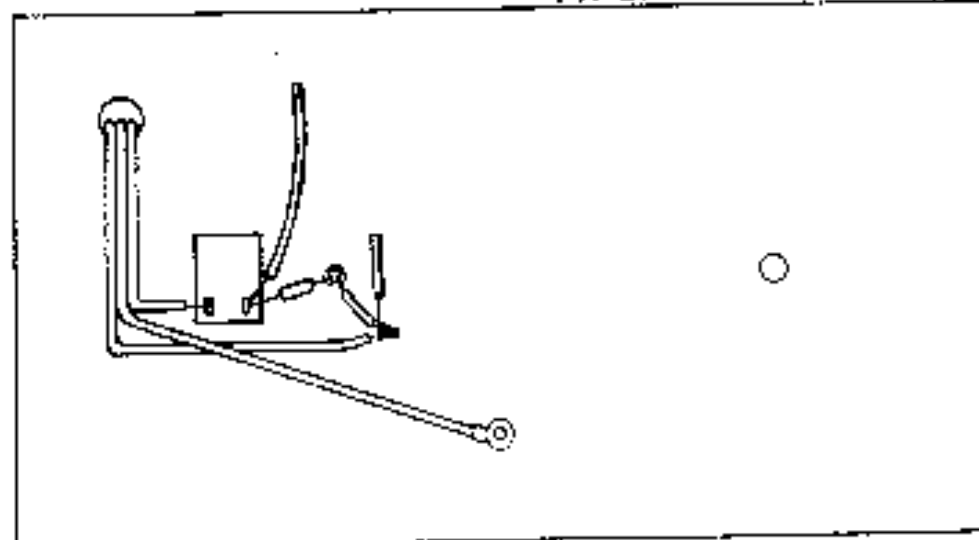
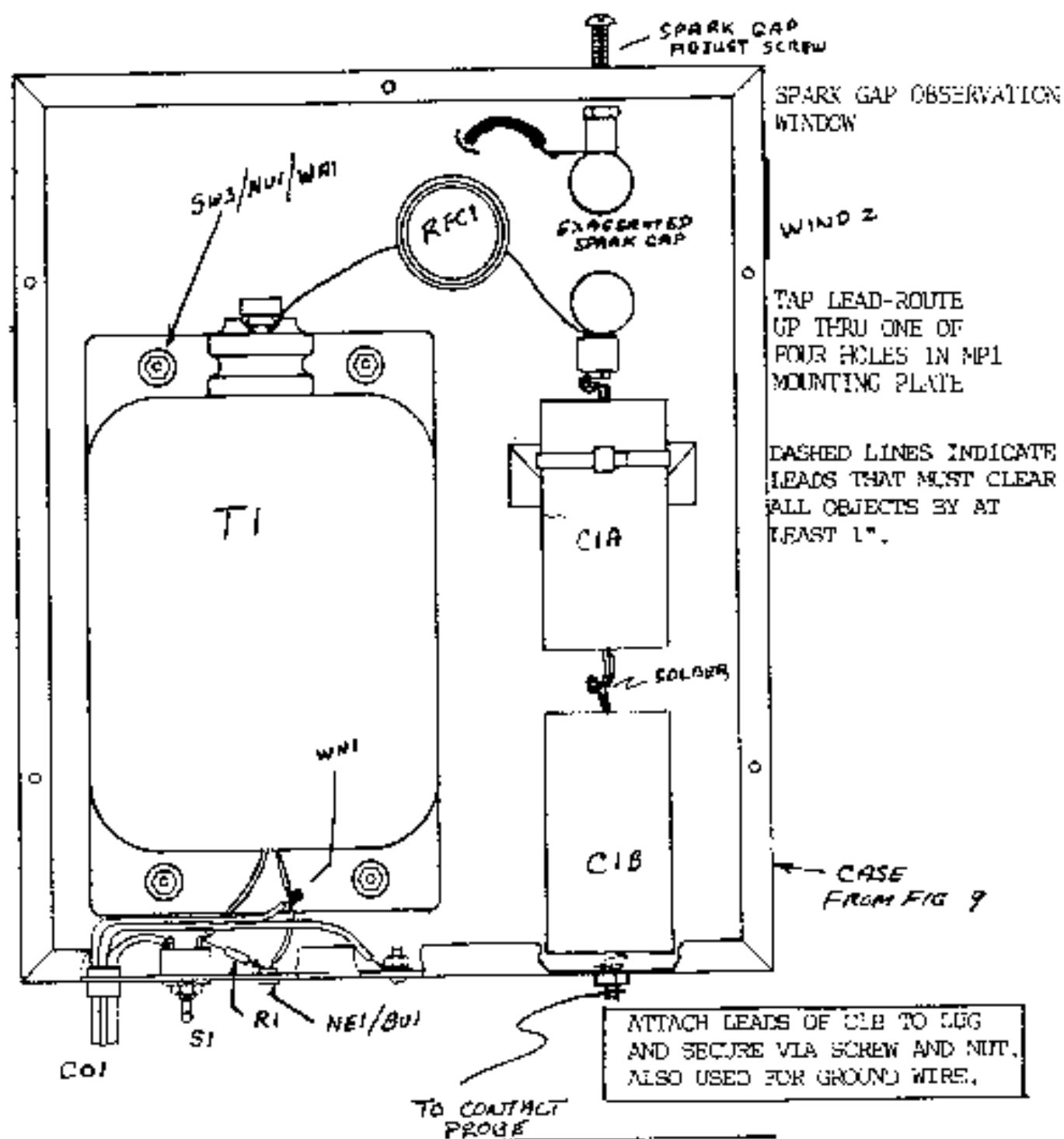


FIG 8 PICTORIAL SHOWING WIRING AND
GENERAL LAYOUT

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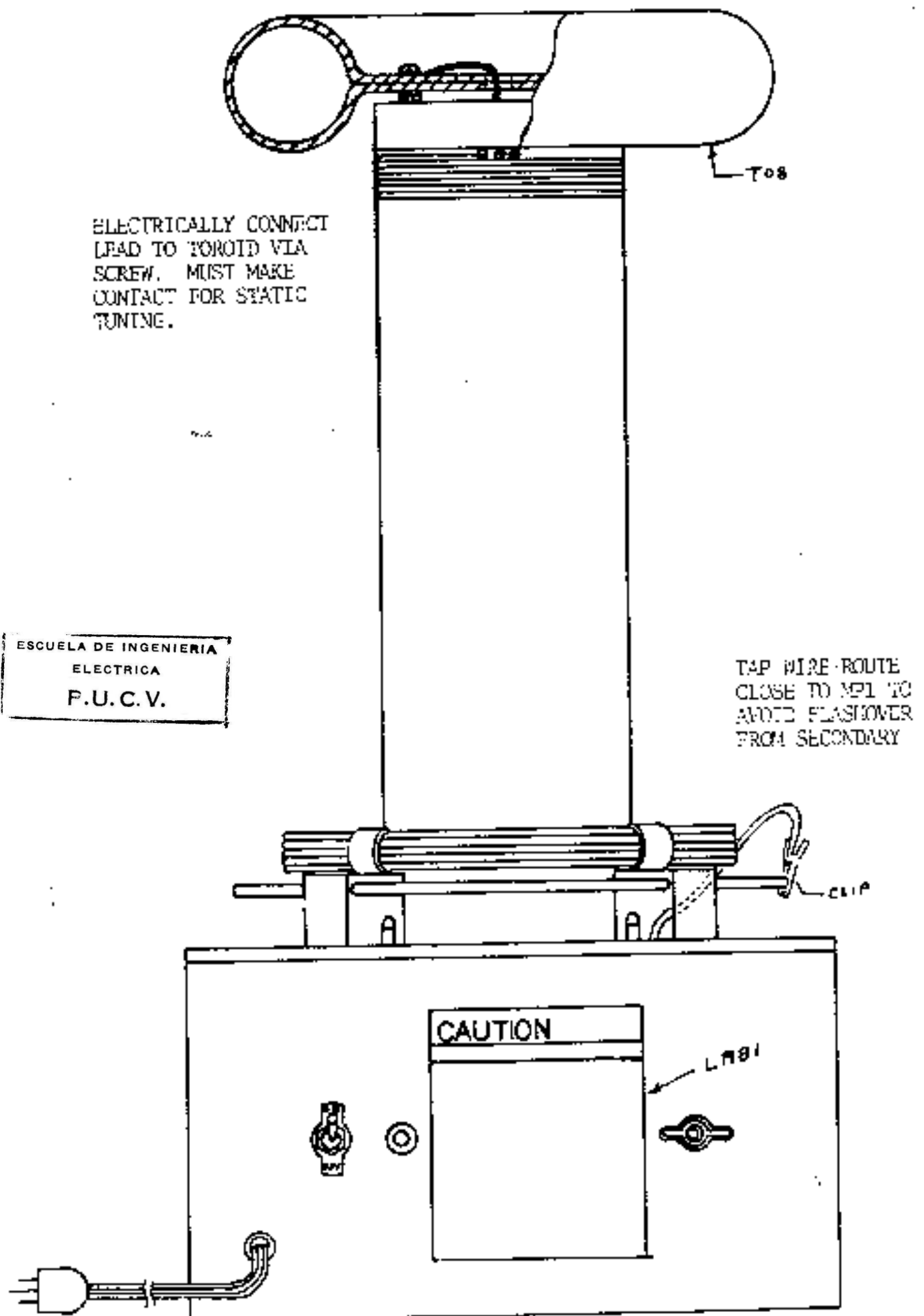
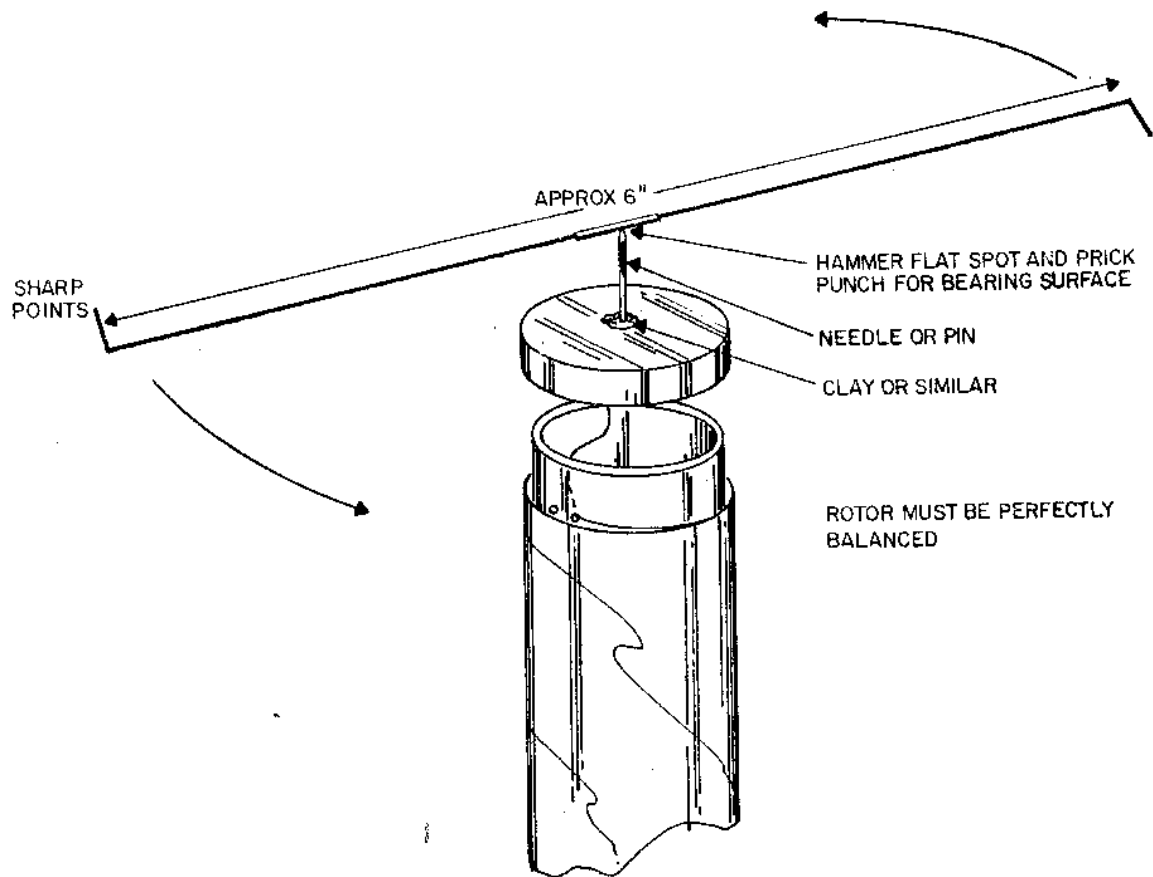


FIG 11 ION MOTOR



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Transcriber's notes:

Finally, the address for IU, where you can get their excellent catalog for free, containing over a hundred books, kits and ready-to-use HV projects:

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Box 716 AMHERST
N.H. 03031, USA

