

Second Report on experiments with N2 Laser using air as laser medium R. Meagley 4/1/00

6/24/00

Ahh Ha! Found a whole bunch of exotic vacuum tubes at a yard sale and now have **HV RECTIFIER TUBES (3 OF THEM)** one in particular is a monster. So soon will begin work on 20 kV supply for 1 meter tube...I will lead shield for X ray emissions, like I did B4 way back in high school :-> (Laser system decommissioned last 2 months, day job getting busy). X rays are typically only from higher voltages (to get any at all I believe 30+ kV and vacuum target (like a tube type rectifier), higher current (so Tesla coils are fairly benign)- not trivial to get efficient X-ray source, certainly one reason I like to keep under 30kv.

5/1 to 4/16- several configurations with tandem 2/3 and 1 M lasers. Parallel configuration allows attempts at photo triggering a spark gap, no success. Cascaded Blumleins do trigger 2 tubes reasonably well.

4/16/00

Adjustments to largest capacitor (1 square M) / choke coil (now tunable 6 cm dia, powered from center tap) and spark gap result in smooth triggering of the 1 M tube. Very bright and tight divergence (exact value TBD). Key seemed to be modifying size and angles on spark gap. Now using a delta shape for top and bottom spark electrodes fabricated from Al sheet (base of triangle is 15 cm, height is 12 cm- all corners rounded off). Electrodes are gently inserted between capacitor plates and dielectric, then spacing is adjusted. Successful laser action also correlates with significantly sharper spark sound. Stormy weather seems to affect the output, with lasing difficult during rain. Many parameters to consider- humidity of the laser gas itself, the effect on dielectric and leakage current as well as spark gap performance, etc. Pressure control is still pinhole leak at one end of laser tube connected at other end to vac pump equipped with an adjustable air bleed.

Experiments performed 3/15/00-4/1/00

4/1/00

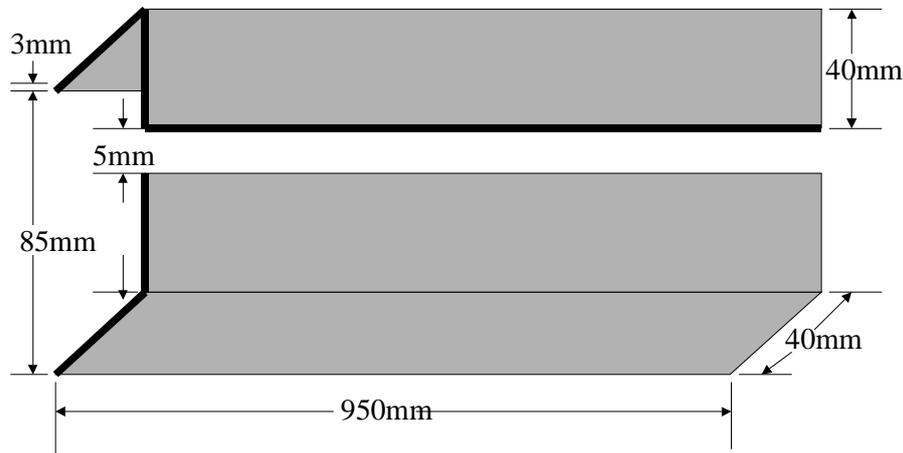
Odd- when I power the big guy, best success has been with two smaller power supplies in tandem. When I try to build a 2X scale up of my largest, it seems too slow and megawatt tube won't lase, yet a pair ganged together is fast enough with similar geometry. I say similar, but the devil is in the details. I will reconfigure the grounding strategy and see tonight.

Later 4/1/00:

Ground now continuous across the two halves of new, 1M capacitor (previously ground connected between the halves at the left and at the right of the 1 M length) and 1 M tube easily lasing (75-85% of pulses lase, perhaps at time nearly 100% depending on gas pressure, flow and pulse rate, also pulse quality- jitter??). Failed pulses have a different sound "tinny". Each half of capacitor is a pair of plates 1 M long X 7" wide with dielectric as 1 mylar sheet (same style as set of images from power point presentation of the design, this is the 2nd factor of 2 scale up of the original design). Plates are folded, with connection to laser at midpoint of sheet (at the fold). Minimal beam divergence noted! Window seems to scatter a fair bit. Found surface degradation from arc proximity on both windows. However, tracked beam for >1 M away from window, and no divergence measurable in central bright spot that was surrounded by halo of scattered light. Long plasma tube definitely much tighter than the shorter tubes. No luck with new dye cell. This is a polystyrene tray from top of cassette box (no lasing from superradiant marker extract) however easy to get even line of UV projected into dye in cell. The 54-cm tubes now retired since it still is as good as new and foil electrodes wont last forever. The 2/3 M tube working fine, ready to begin learning how to trigger on with other (photoactuation reported to be very fast). Rectifier heating is becoming more noticeable, need to obtain another couple for upgrade (tubes?!?!)

1Meter Tube:

Electrodes & Channel



3/24/00

Got 2 more lasers cooking. Collection is now 54 cm (3/9 report), 60 cm & 95 cm. Electrode thickness goes up much faster than length in these devices (foil in the first tube was replaced with aluminum flashing in the second tube, while 1/8" Al angle stock used in the 1 M laser tube) as does current demand. Sum of all capacitors just barely enough to trigger the 1M tube- nice bright spot on a postit, but not reliable enough (power HUNGRY!) to check out dyes- Fried capacitor instead (reflected power due to impedance mismatch?) with the 1M tube (Kerpow!). Built a new one, but need to rework geometry, too high reactance (ground goes round the long way- duh). 60 cm tube very nice and reliable- gotta package this one for road trips, its pretty tough. Got rep rate on 54 (and nearly as good on 60) cm up beyond 15 Hz with new style capacitors. No dyes tested yet have become superradiant and lased w/no mirrors, but dye cell and dyes are CRUDE (need quartz tube and flats and a couple mirrors with an optical bench...). I noticed my dye cell focused the beam into a nice neat spot (attenuated by the dye, of course).

3/19/00

Mylar dielectric is 50% higher K than PE (better breakdown by far :->) with stack of eight 7"X10" plates, this morning could easily trigger 54 cm laser. With this evenings eight plate 16X22" (!) capacitor have, I think optimal power supply for 54cm tube (according to literature this is ~100 kW per 4ns pulse). I can get the device up to and, perhaps, exceeding 10hz with nice bright output over a fair range of pressures (Shall I gang the 7X10 with the 16X22??). Rectifier begins to heat with high rep rate, so I do in bursts of a few seconds- brrrrapp!!!!!!!!!!!! brrrrapp!!!!!!!!!!!! brrrrapp!!!!!!!!!!!!!! Been looking at dyes extracted from highlighter pens. Orange gives a nice fluorescent line through fluid in 5ml round bottom flask. Green absorbs so beam is just 3 mm deep glowing spot in flask. Yellow (fluorescence?) was disappointing, perhaps glass vial was acting as UV filter- no reaction in vial, even though this stuff lights up when spot on paper is zapped. Antifreeze is supposed to be a good candidate. Goal is to find dye stuff (or dyed stuff) that is superradiant (laser w/no mirrors, like N2 plasma) and have a simple N2 laser pumped dye laser. I may just go ahead and order the quartz tube, windows and flat mirrors and build a proper dye cell, but want to mess around w/ more off the wall things first. I did not get to the store today and so still need silicone seal for 1M laser under construction as well as second 1/2 M tube also under construction. I have schemes in mind for series of two, with one as signal generator and other as

amplifier (guess which order). Stanford Linear Accelerator (SLAC) paper indicates this is a great way to get a very tight beam. My first tube still gives ~1.5-2 degrees of divergence. I've been wondering about the holographic possibilities- after all, with 4 Ns pulse, not much time for optics to vibrate and subjects to move. With nice intense light source, ought to be easier than with a weak HeNe laser. Still no luck with 1 atmosphere- I think issue is with voltage. I am sticking to 5-9 kV (I have seen turn on with ~2 kV under some conditions). At 1 atmosphere, this is not sufficient to make much of a corona around the electrodes before the pulse, so discharge is irregular. This would not be the case at 20-30 kV. Trade off is speed is thin dielectric, but lower voltage. the Mylar is thin enough I ought to be able to get away with 3-4 layers and still be within the polyethylene capacitor params. I do not trust my 28 kV diode to the 20-30 kV realm, since the current current demands (present amperage requirements ha ha) are already pushing the thermal characteristics of the diode. I like Russian Venus probe engineering (tough as nails, redundant and brute force solution) so I deliberately targeted 10kv and over-engineered, figuring I inevitably would push one or another param beyond design specs (like repetition rate). I want my vacuum tube rectifiers!!! I had 2 in Jr. College and can't find them in my parts here (though I did find my 1 KW RF amplifier tubes, my 20 Ghz triode etc...). Those guys would handle the juice (ok so what's a few soft x-rays...).

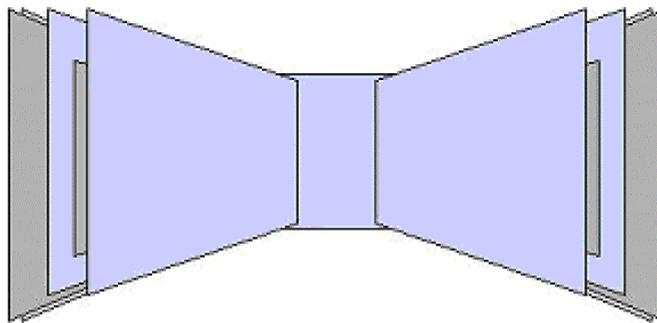
3/18/00

An advance in capacitor design that has reduced footprint factor of 4. polyethylene sheet is MUCH weaker than overhead plastic (acetate sheets?) and the overhead is thinner and has higher dielectric const. am extracting fluorescent magic markers (highlighter pens) for dye laser...

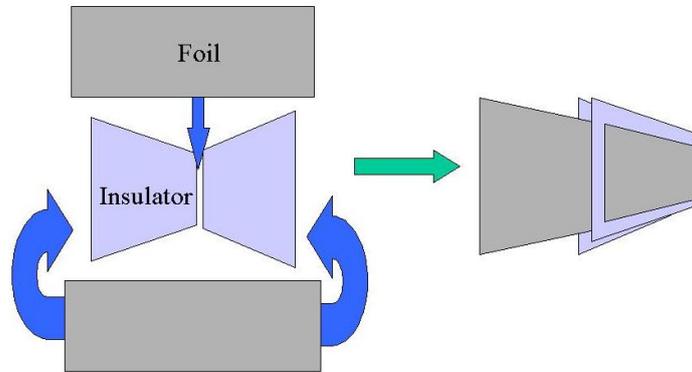
Later 3/18/00 overhead is probably Mylar

3/17/00 Images from presentation on new capacitor design

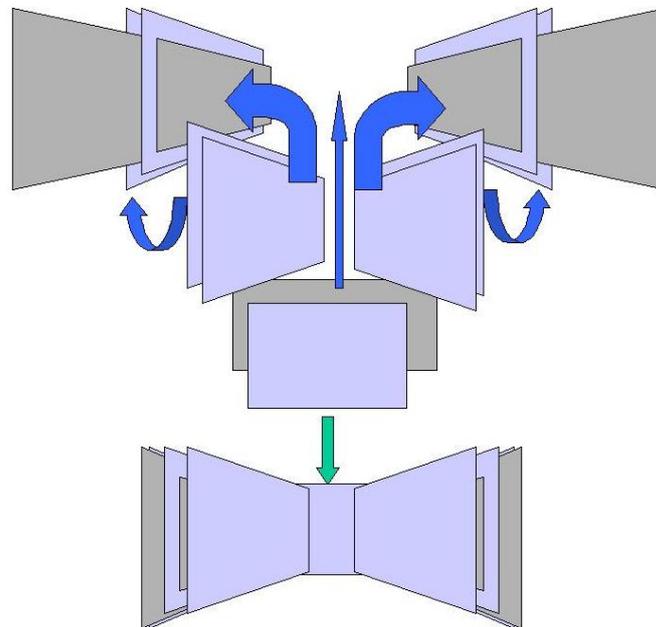
Split Stacked Plate Capacitor R. Meagley 3/17/00

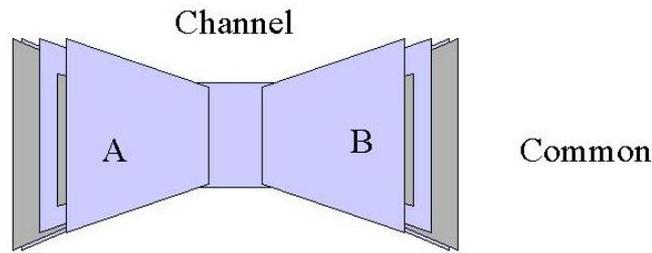


One Half of the Capacitor (4 plate)



Interconnection & Insulation





- Split 4 plate (2 pair 4 plates each) capacitor
- Foil and “overhead” (acetate?) construction
- Tested to 9kv
- Design can be expanded to n plates
- Additional layer interconnects reduce inductance
- Fold A to B to reduce size and make edge channel

3/15

Trying to find a source of thin metal sheet so able to make more robust electrodes. 1M tube uses angle stock. Stacked capacitor has lower inductance for size (higher efficiency), verified with expts on traditional design.

Report on experiments with N2 Laser using air as laser medium

R. Meagley 3/9/00

Experiments performed 3/8/00

Nylon track (5.5 cm wide X 1 cm thick with center groove measuring 1.5 cm wide X 0.5 cm deep) was used in 2 pieces to fabricate 2 halves of a cavity measuring 53 cm X 1 cm. One half was drilled and fitted with a plastic inlet port (7 mm od), while the second half was equipped with 2 parallel Al foil electrodes (5 mm gap width, 48 cm long) which were affixed with RTV. The halves were then assembled and sealed with RTV to form the plasma tube. The plasma tube was then closed with polystyrene windows (1.5 mm thick X 4.5 cm X 2.5 cm) and heavy double stick tape to complete the laser (**Figure 1**).

The laser was connected to Blumlein style switching system. This switching network consisted of a 3 pair (hot and ground plates form a “pair”) stacked parallel plate capacitor. Of the three pairs of plates, 2 pair were assigned be voided by an air spark gap to ground. These two pair of plates were directly connected in parallel. The remaining pair was assigned the role of driving the laser and was connected in parallel with the first two pair through a choke coil. This network was powered with a 7.5 kv neon sign transformer driven by a variac (**Figure 1c, Figure 2**).

Once connected to the vacuum system, evacuated and powered up, the laser became resonant with minor adjustment of the pressure in the system. For analysis, the image of light from the device was projected onto a fluorescent screen. Resonant behavior was denoted by a transition in the projected image. Non resonant behavior was characterized by a rapidly diverging image the exact shape of the window on the plasma tube. Resonant behavior was indicated when the image became a bright narrow line, parallel with the electrodes in the cavity and quite narrow in beam divergence. However, the laser activity was intermittent and rather weak. The windows were removed and sealant was replaced by RTV. After 3 hours of curing, no laser activity was able to be elicited from the device.

Experiments performed 3/9/00

No laser activity was able to be elicited from the device after 24 hours of additional cure time. One window was removed and replaced with a small first surface mirror, affixed with double stick tape. After adjusting the pressure, resonance was observed over a wide range of pressures, spark widths, pulse rates and voltages. Several choke coils were tested and a fairly wide tolerance was confirmed. Some measurements on the beam characteristics were made. At the window, the beam consisted of two parallel emissions, 14 mm wide X ~1 mm thick separated by ~5 mm, positioned above and below the plane of the electrodes, parallel to the electrodes. At 3.5 meters away, the beams had diverged to two parallel beams, ~1-2 cm thick, 110 mm wide, separated by 135 mm (**Figure 3**). It is noted that after operation for several pulses, beam intensity drops off and becomes intermittent. When the cavity is inspected by removing the mirror, an acrid odor is noted, reminiscent of NO_x; thus, this is interpreted as confirmation of reports that nitrogen oxide formation can interfere with the efficiency of emission.

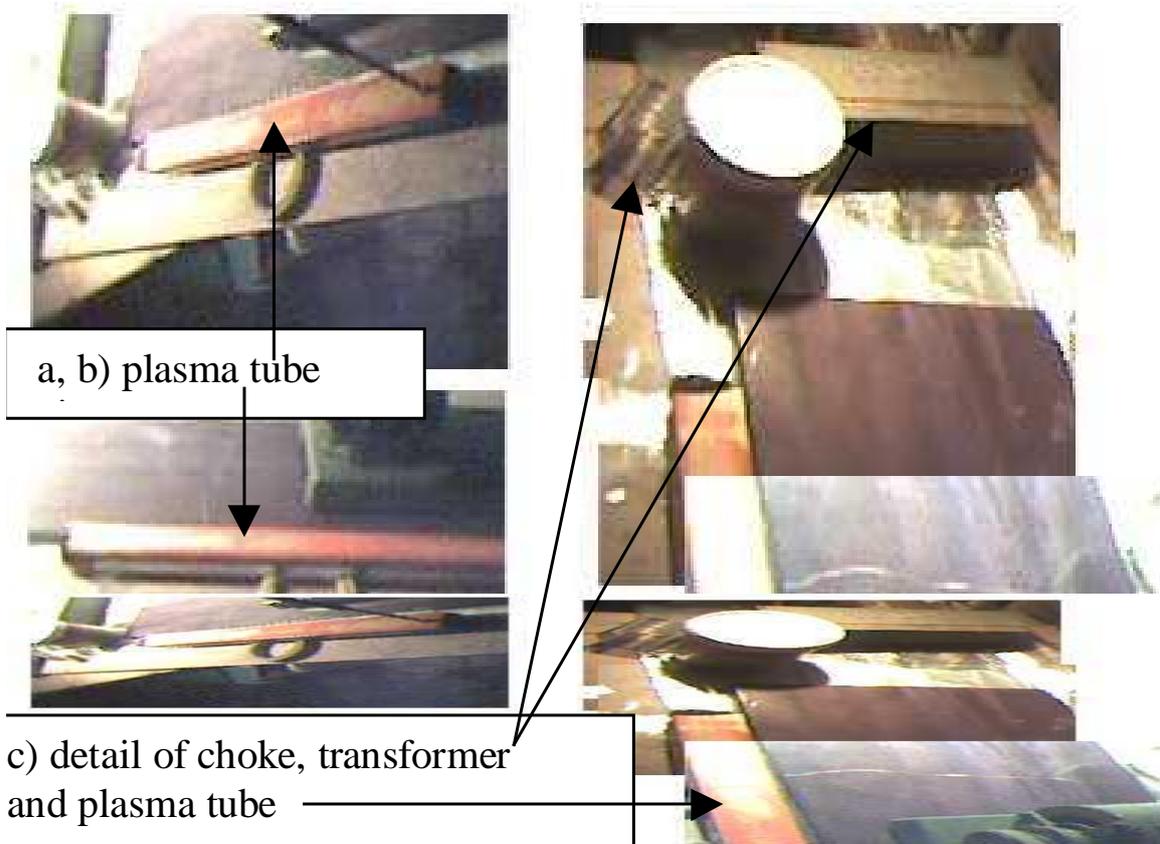


Figure 1. 1st generation N2 laser

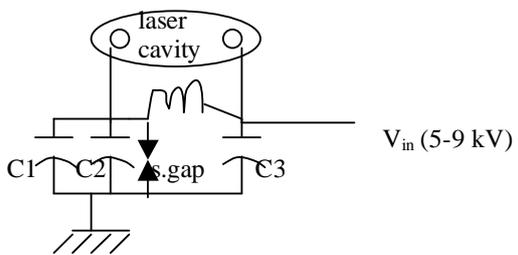


Figure 3. Power supply

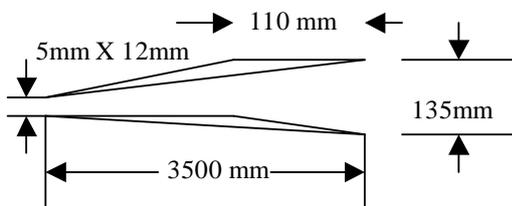


Figure 3. Beam divergence measurements