RECTIFIER X-RAY MACHINE

Before my Coolidge X-ray machine, I did my share of lesser x-ray experiments in an attempt to find the most easily reproducible means of creating an x-ray machine. The reason for this was the high cost and rarity of x-ray tubes or heads, and the success of others using common high voltage rectifier tubes. The idea behind these experiments is to turn common vacuum tubes into x-ray emitters, by operating them well outside of their normal operating conditions, in cold cathode mode. I suggest you read my Coolidge X-ray machine article as well, as it contains some relevant information.

High voltage recifitier tubes. American 2X2-A on the left, and CV-1290 on the right.

SAFETY: Before you read any further you should be aware of the dangers associated with conducting x-ray experiments. If your common sense suggests that this is utter madness then you're predisposed for safety, which is good.

Otherwise I'll need to scare you with some quick facts. X-rays are ionizing radiation just like gamma rays, which means exposure WILL cause damage to living tissue, which in effect increases your chances of CANCER. Yes, the terrible disease you've heard so much about. Ionizing radiation can pass through low density materials with the ease of light through glass, so the only real protection is distance and thick, dense shields. As though X-rays aren't scary enough already, they can also reflect and scatter, sending X-rays in completely new directions so a directional shield isn't enough. Think of an X-ray tube as a lightbulb, if you can see the light it emits, you're not entirely safe.

Early Marx Generator Experiments

Initially I tried to operate the rectifier tubes as a flash tube, by using a Marx generator as the high voltage source. The benefit of this is low average current through the tube, so heat dissipation doesn't become an issue, and hence the ability to largely choose operating voltage at your own desire. This is contrary to DC operation, where the tube is run at a set DC voltage and current which depends on the voltage and tube characteristics. The tubes often behave as zener diodes, that is having a sharp increase in current at some voltage. Since these tubes are only suitable for a few tens of watts dissipation, the voltage you can run a tube at in DC mode is quite limited. Another benefit is the relative simplicity of constructing a Marx generator, as opposed to a DC power supply of 30-50kV.

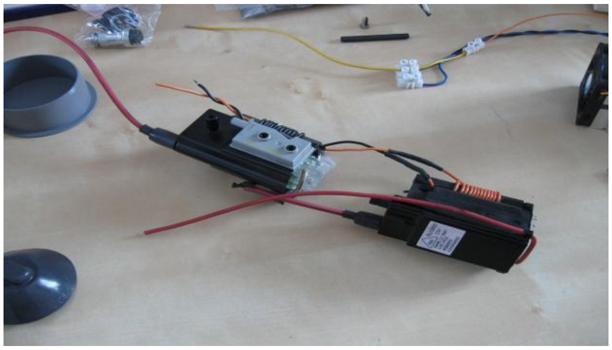
Marx generator and shielded 2X2-A rectifier.

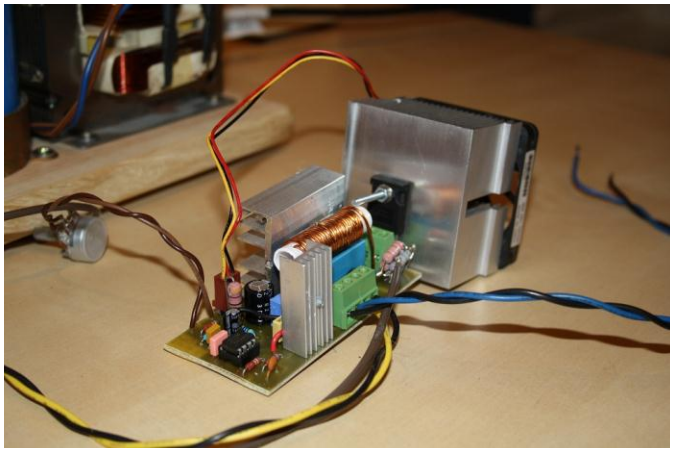
The idea was to discharge the 180kV Marx generator through a 2X2-A rectifier tube, thus causing a massive burst of high energy x-rays. Leslie Wright had great success doing this with other tubes, and his work was a motivating force in these experiments. Unfortunately he has since removed the all webpages regarding his technical x-ray work. The photo above shows the x-ray setup I used, the rectifier tube itself is behind a 30mm steel shield and submerged in oil to prevent arc-overs. Sadly, this setup never proved capable of producing x-rays. Later I found this was due to the small capacitors I had used in the Marx generator. Each capacitor was a mere 470pF, meaning that the erected Marx capacitance was 470pF / 20 stages = 23pF. This is roughly equivalent to the capacitance presented by the load (rectifier tube under oil, feed wires, etc) if not less. Therefor the voltage across the tube itself at each firing would only be a fraction of the 180kV present without a load.

Later testing revealed that the tube conducts first at 40kV, which explains why this setup was never able to produce x-rays. Had I known this while experimenting, simply rebuilding the Marx generator using 4.7nF or larger capacitors would probably have given results.

Flyback Transformer Driven Experiments

It wasn't until seeing a thread in the 4HV forum that I became inspired to work on a rectifier tube x-ray machine again. Radu had done some experimentation, and achieved incredible results using very simple equipment. The entire thread is well worth reading. He used the same model of rectifier I had and powered the device using an AC flyback driven by a ZVS driver. This prompted me to start working on a flyback stack which could provide 60kV (or so I hoped). The driver used was based on a current mode switch regulator, and designed by Jan Martis. This driver regulates the mosfet/IGBT current, which means overcurrent will never kill the switching device (high temperature still can) and output power can be directly manipulated by turning a single potentiometer. These two properties make this the ultimate flyback driver.

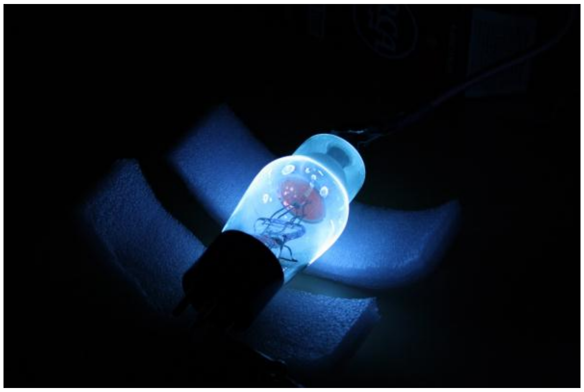




The two flyback transformers had their windings put in series, secondaries and primaries respectively, then submerged in oil. To ease experimentation, a rig was constructed which held a rudimentary radiation shield, the oil submerged flybacks and a ammeter for monitoring the current through the tube. In addition to this a timer unit and relay were used to control exposures.

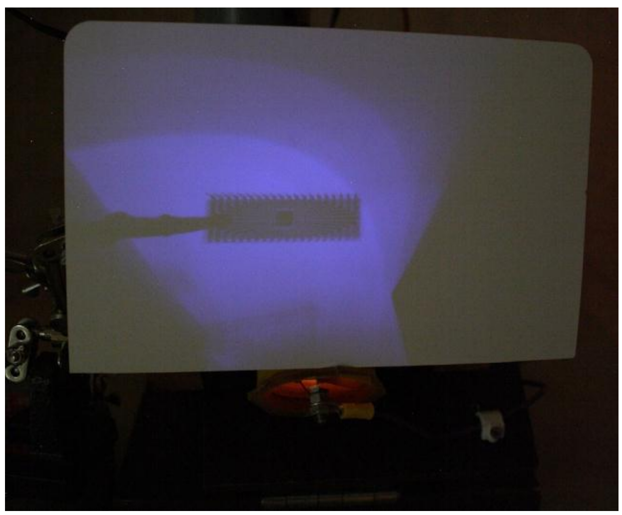
The vacuum tube can be operated in one of two modes, either with correct or reverse polarization.

In neither case is the filament heated, at least not intentionally. As mentioned above the tube will behave as a zener diode, and begin to conduct once a certain threshold is reached which depends on the operating mode. Due to glass walls the tube voltage should be above 20kV, otherwise very few of the x-rays will penetrate the tube itself. Simply powering the tube without the intention of x-ray production is entertaining in itself, as the electron bombardment causes the glass walls of the vacuum tube to fluoresce, and the internal structures to glow red with heat. Care should be taken though, as copious amounts of x-rays are produced if such a light display is visible.



I was successful in taking x-rays using ths simple assembly, though no where near the results Radu achieved. He had kindly sent some fluorescent screens taken from dental image intensifiers, which I used along with a DSLR camera to take some x-ray images.

The photo below is the best of the entire lot, requiring a 30 second exposure at a wide aperture (3.5), and later digital enhancement. However, it proves the concept is viable.



The x-ray above was taken with an American 2X2-A rectifier tube, at 44kV and 210�A. Due to the low voltage and current, only plastics can be x-rayed as much denser materials provide too much attenuation.

Source: http://uzzors2k.4hv.org/index.php?page=tubexray