

PARTICLE ACCELERATING CYCLOTRON

ALSO SHOWN ARE EXPERIMENTAL VERSIONS
FOR ATOMIC MANIPULATIONS AND
ELECTRON/PROTON ADDITION/DEDUCTIONS.

What is the cyclotron?

A cyclotron is an accelerator for charged particles. In 1931, E. O. Lawrence and M. S. Livingston developed a method of cyclic particle acceleration that produced high energy ions without using a high-voltage source. Because of the cyclic paths of the ions, this accelerator was named the cyclotron. The cyclotron operates on the principle of particle mass resonance. The device uses two hollow D-shaped electrodes held in a vacuum between poles of an electromagnet. A high frequency AC voltage is applied to each D. In the space between the Ds, an ion source produces positive ions. These ions are accelerated into one of the Ds by electrostatic attraction, and when the alternating current shifts from positive to negative, the ions turn and accelerate into the other D. Because of the strong electromagnetic field, the ions travel in a circular path, their path of least resistance. Each time the ions move from one D to another, they gain energy, their rotational radius increases incrementally and they produce a spiral orbit. This acceleration continues until the ions escape from the Ds. As they make revolutions in the Ds they spiral out into circles of larger radii so that the path length of the ion increases as it gains more energy. The added path length compensates for the increased velocity of the particle.

Here are some formulas that may help in calculating :

ions go in circular orbits according to: $F=qv(B)$

F is the force vector, q is the charge, v is the velocity vector, and B is the magnetic flux density vector.

Acceleration of the particles according to: $F=qE$

E is the electric field vector.

The electric field has to oscillate with a frequency which is corresponding to the particles' revolution frequency. If this condition is met and we assume that the magnetic force is

equal to the centripetal force of the circular movement, we can use the cyclotron equation:
 $r = mv/qB$

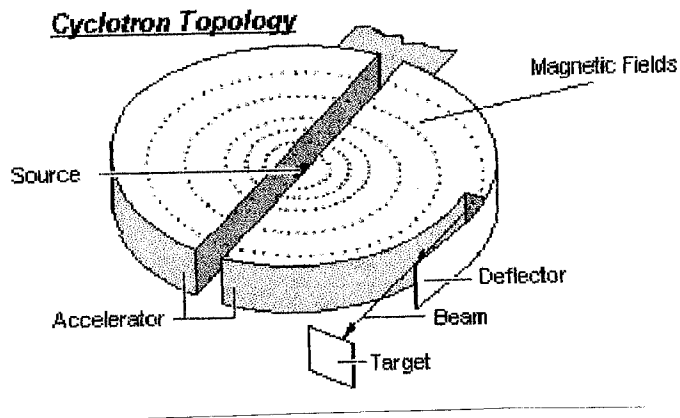
r is the radius of the particle orbit.

The ions are formed by the ion source and are drawn out by one of the Ds. Period of orbit equals period ($2\pi / \omega c$).

BASIC MAKEUP OF THE CYCLOTRON

The Ds are contained within a vacuumed chamber which is at a level of 10^{-5} mmHg. One of the Ds has a corner taken out of it for particle bombardment or aiming the beam of accelerated ions. The ions originate from the ion source located at the center of the Ds. The ion source is made of .1 ohm nichrome wire wrapped around a pipette of borosilicate glass, through which ran one leg of the heater coil. Use ceramic insulators to hold everything in place. Sufficient current was applied to achieve a high ion emission without burning out the coil. Note that the Ds are made of hollow brass. We made ours by cutting thin sheets of brass and soldering them together. The accelerator makeup is the space between the Ds. A deflector is required to hold the beam together and also for accuracy of bombardment. The target is placed in front of the beam and the device is energized once with 3-5kv to degas the Ds.

Here is a basic diagram of the cyclotron:



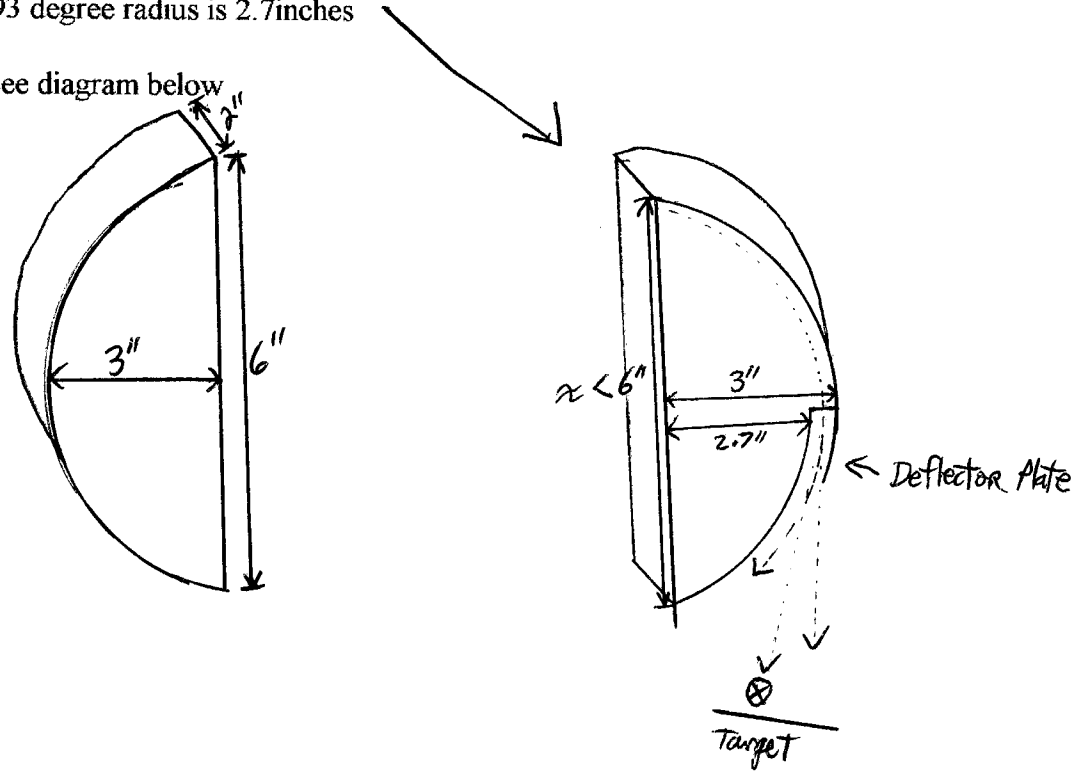
BASIC SPECIFICATIONS

Size of the Ds must be correspondent to the accelerator gap using the above equations. A good size to use is 6 inch diameter and 3 inch radius with a two inch thickness.

The D with a cut out has the following specs:

- d=6inches
- 90 degree radius is 3inches
- 93 degree radius is 2.7inches

see diagram below



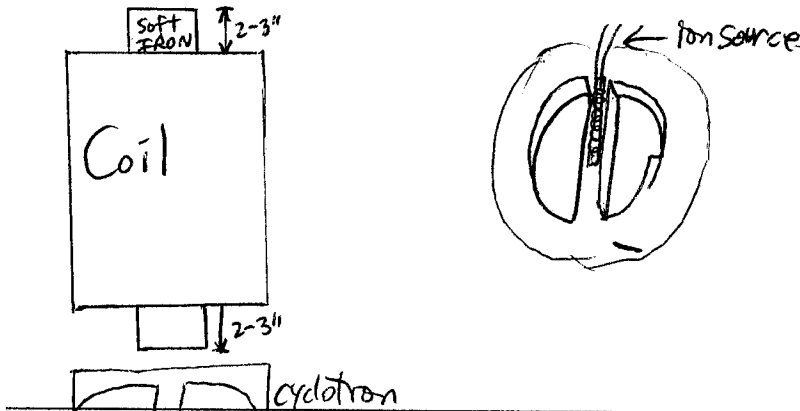
ELECTROMAGNETIC COIL SPECS

The cyclotron uses an intense magnetic flux to bend ions into spirial orbits. You will need to design the magnets according to the equation: $B = \mu_0 N i / g$

- $\mu_0 = 4 \frac{1}{4} \times 10^{-7} \text{ Tm/A}$
- $N = 2000$ number of turns
- $i = 22.2$ amps in coils
- $g = 0.06985$ m gap between the magnet poles
- $B = 0.7987 \text{ T}$ or 7887 gauss at 22.2 amps

You must connect the magnets up in series not parallel. Use soft iron poles for the magnet designs. The poles should extend about 2-3 inches on each end of the coils. See diagram below: you want two kilowatts through each magnet. Use a variac to vary the voltage and a rectifier to turn the ac input to dc output into the coils. Use capacitors to filter any ripple from the dc. Use a 40a variac, a 35a rectifier and a 40a relay if required

for switching. The wire in the magnets cannot handle more than 22.2amps. you must achieve the highest possible flux density. A good wire gauge to use is between 16-22 ga.

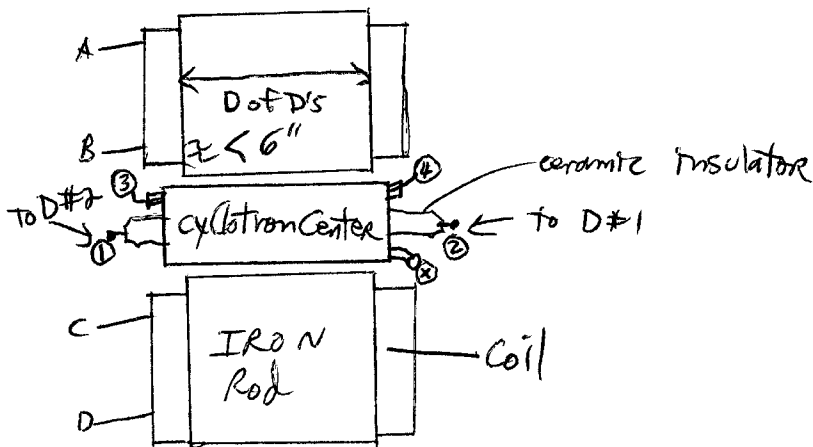


HIGH VOLTAGE POWER SUPPLY

A high voltage, variable frequency power supply is required to provide the attractive and repulsive force needed to deflect ions into their orbits. You will need a .5MHZ to 17MHZ signal. The output should be 1300-1500 volts at 400-425 watts. Shortwave radio or some other type of high power communications transmitter may be useful.

Everything must be insulated using ceramic insulators. The top and bottom of the chamber is made of thick glass, the side cylinder is made of a piece of steel pipe cut out perfectly. Make sure there is about 1 inch between the Ds and the outer cylinder.

DIAGRAMS OF DEVICE.

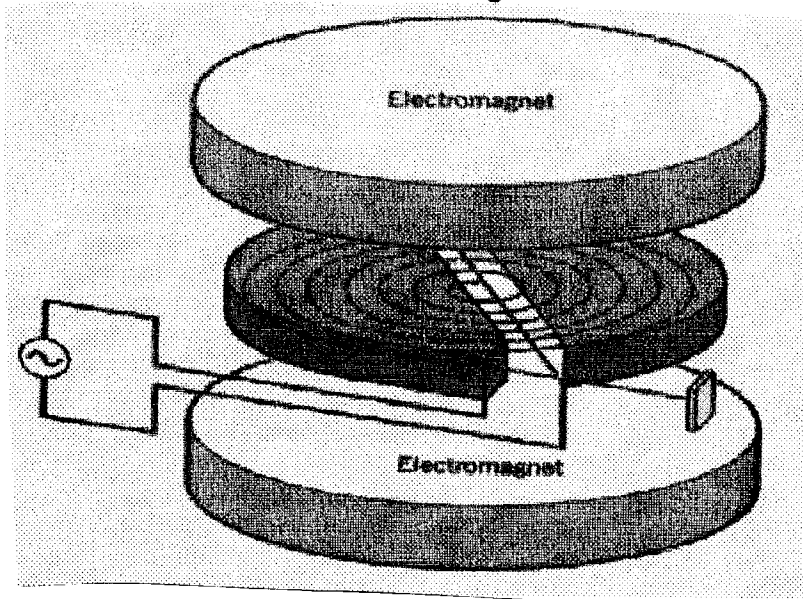


magnets
 ⊕ to A
 B to C DC
 D to ⊖

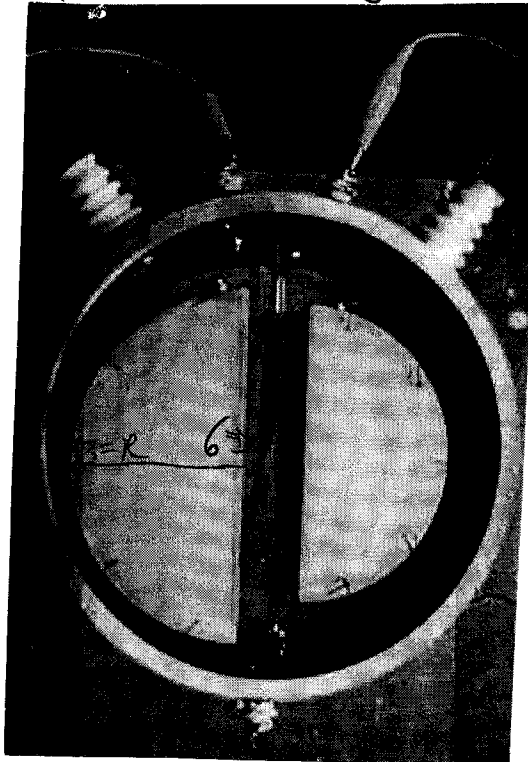
Ion Source
 3 to ⊕
 4 to ⊖ DC

high freq/high Volts
 1 & 2 to output of
 Generator
 ⊕ to Vacuum
 Pump.

Similar Design



Another Design



exposed



complete

PLEASE TAKE NOTE THAT THIS DEVICE EMITS LARGE AMOUNTS OF RADIATION. IF YOU BUILD THIS DEVICE YOU ARE COMPLETELY LIABLE FOR ANY AND ALL DAMAGES, DEATH, HARM, PROPERTY DAMAGE, ETC.

USE SHIELDING OR PROTECTION BEFORE AND WHILE USING THIS DEVICE.

EXPERIEMENTAL DESIGNS.

