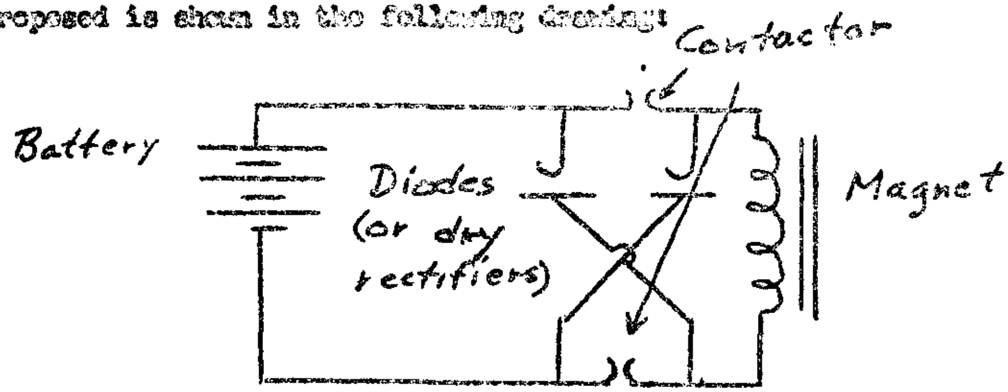
Report on Magnetic Measurements at Brookhaven

Most of the material here was obtained from Dr. G. K. Green,
and Dr. R. A. Beth.

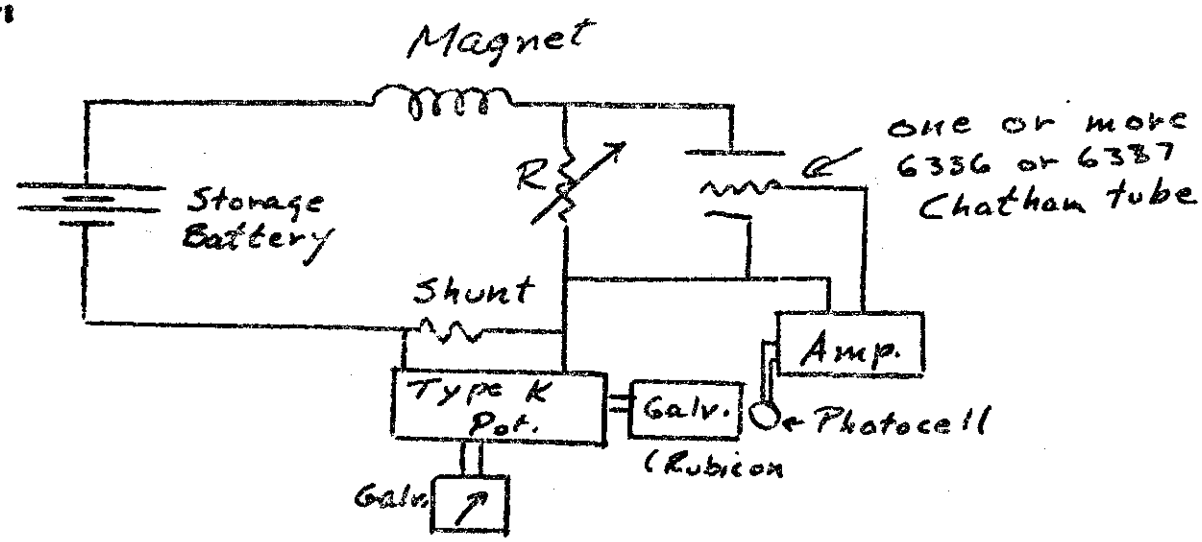
The group is now making measurements on a half-scale D.C. magnet with hyperbolic pole faces. The poles are removable on the model and new pole shapes will be tried. A cross-section of this magnet is given in the report of Cal Lasky dated June 10, 1954. They have not yet tried turning around the poles to see if a - section has the same field as a + section. The program from now on is to complete the measurement on this model including trying different shapes of poles. They are quite confident that the high field measurement with D.C. will be just the same as high field A.C. measurements would be.

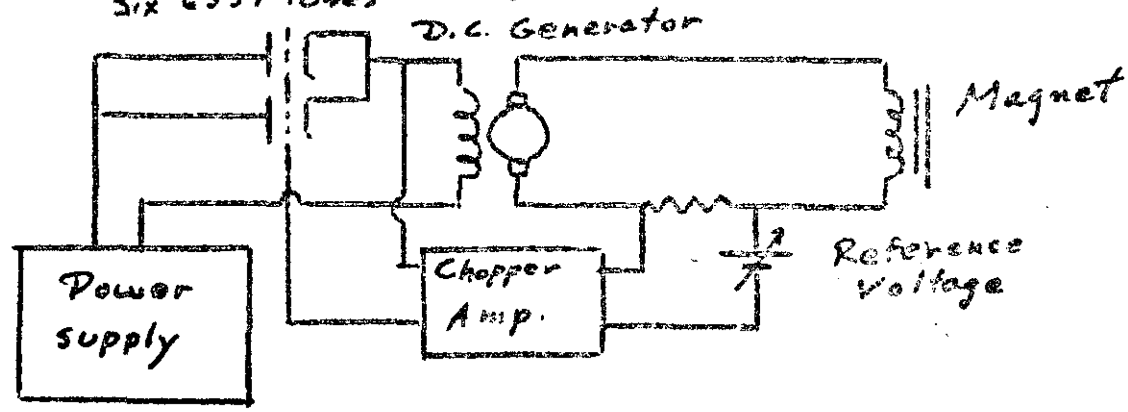
The second stage will be to make an AC model for low field tests. If these are satisfactory the third stage will be to make proto-type magnet which will probably be a full length double sector (both + and - sectors) identical to the final magnet. This will give power loss etc. and will give a final check on the field. If the AC model does not do well it may be necessary to make another AC model before building the proto-type. Since probably the final magnet will have the coils in all sectors in series, putting power into the proto-type will be difficult. In order not to have too high a voltage on the whole magnet, the voltage on any one double sector will only be about 30 volts. The peak current will be about 6000 amps. In order to determine the remanent field in the gap, it will be necessary to apply the same shape of current pulse to the proto-type as the final magnet will get. There are several methods so far proposed for this. The first is to put it in series with the cosmotron for remanent field tests. This might be dangerous and also might take valuable cosmotron time. The second would be to make up a 12 phase ignitron system as in the cosmotron but feed it off the line rather than use a flywheel. The third system so far proposed is shown in the following drawing:



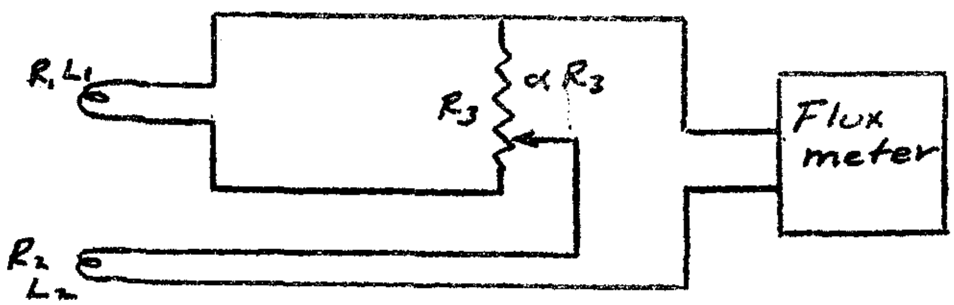
When the contactor is closed, the current will build up in the coil. When the contactor is opened, the current will continue to flow through the diodes and backward through the battery, giving just the required current pulse if the diode drops are not too large (or if they are compensated by batteries).

All of the measurements which I saw are on D.C. magnets. The current in the magnets is regulated very carefully. Two circuits for this are shown below:





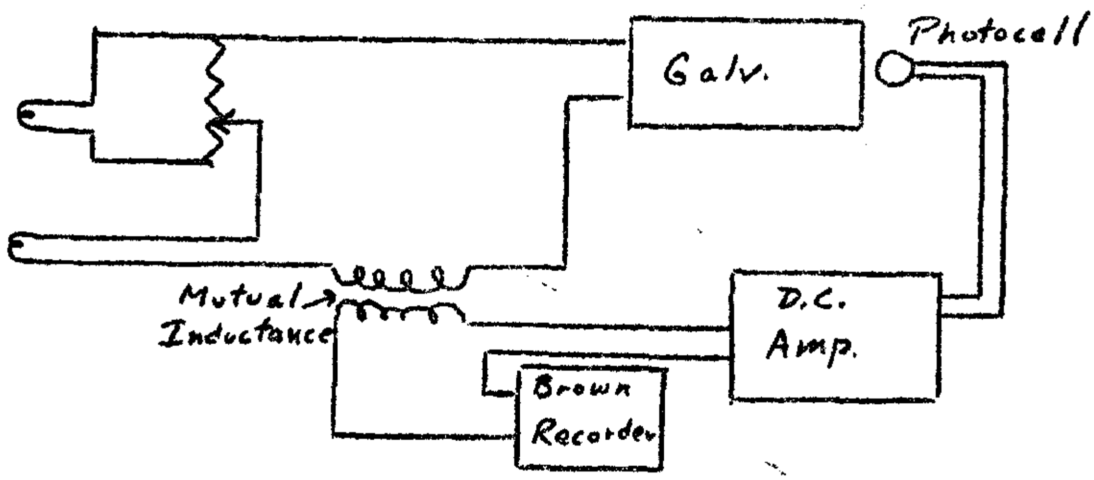
All of these measurements so far are with coils. These are wound on forms about 1 cm. diameter and 1 cm. long. The best materials for forms are soft marble or linen base bakelite but many of the coils are made of lucite which may warp. Coils should be aged for a month before use. Coils are calibrated to 1/4% at the Bureau of Standards. To check and compare coils they have constructed a Helmholtz coil which will give a field of about 200 gauss uniform to 0.1% in a 3" sphere at the center. The frame is made of aluminum. To compare two coils they flip them in this uniform field using a circuit like this:



Using a precision resistor box for R_3, if the fluxmeter indicates no net charge during flipping, the ratio of the constant of the two coils is: $R_1 + R_3 / \alpha R_3$

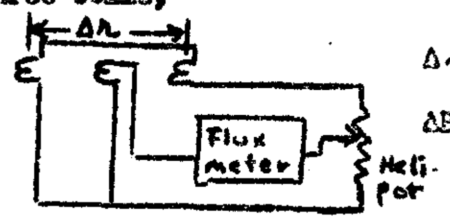
(The coils are bonnected bucking, of course)

For fluxmeters they use the G.E. fluxmeter with a sensitivity of 1600 lines/div. They do not like the more sensitive G.E. coils because they require too small a resistance for the search coil. They also have a servo fluxmeter with a sensitivity of about 10 Maxw/div. for matching coils accurately. The circuit is the following:



In measuring the ratio of coils it is necessary to use only clamped joints, not soldered joints, and to be careful of thermal emfs. The emfs measured are of the order of 10^{-8} to 10^{-9} volts!

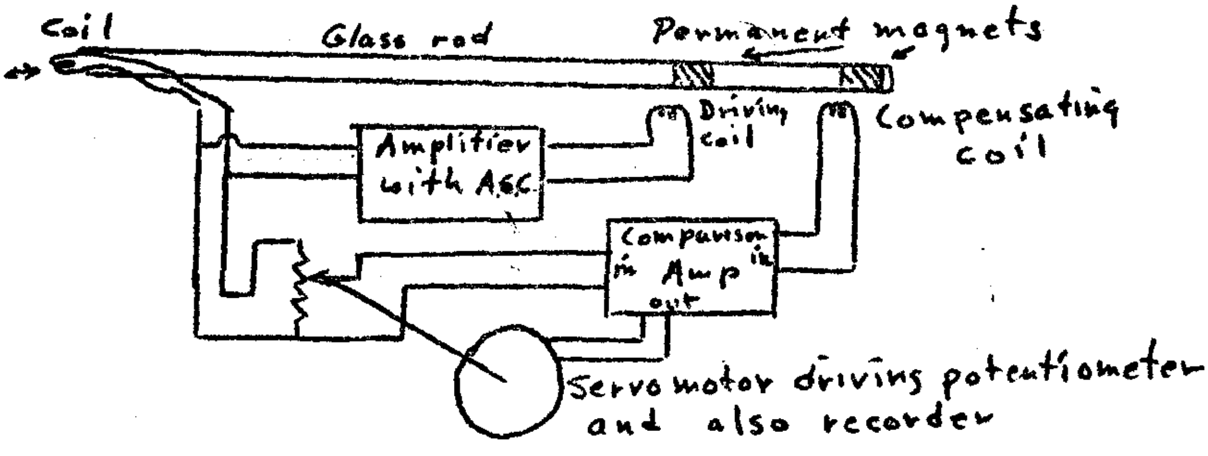
To measure field gradients they have several schemes. One is a set of three coils;



Δr must be measured exactly.

$\Delta B/B$ is measured by the setting on the helipot or precision potentiometer. This measures $\lambda = \Delta r \times B/\Delta B$

Another scheme for measuring dB/dr uses a vibrating coil:



The recorder is set up to record automatically. The system is slowly moved in the radial direction as the graph paper is moved and the pen records the setting of the potentiometer shown. This system must be calibrated in a known gradient. R. A. Beth has designed an air core coil which gives a gradient uniform to about 0.1% in a 3 sphere. It consists of four long coils in an arrangement shown by Shortly and May, Journal of Applied Physics 16, 841 (1945). This showed only single wires while the coils made at Brookhaven have many turns. This gives a gradient of 15 gauss per cm. It was wound on a bakelite form so it would be possible to pulse it.

MISCELLANEOUS BITS OF INFORMATION:

E. Maher and R.R. Kassner, at the time of building the cosmotron, made some magnetic tests on steel bar samples from Cosmotron blocks. Samples from the same heat would sometimes vary in μ etc. by 10% or so. The variation from heat to heat was even greater. It is important in handling samples not to shear them, and not even to stamp a number on them.

General Cement liquid dope is good for cementing measuring coils.

They have a Varian Associates proton resonance fluxmeter which they can use to calibrate fluxmeters etc. It does not seem, at present, satisfactory for measuring fields with any appreciable gradient.

Amplidynes seem rather noisy for holding currents constant in magnets.

Amplifiers, choppers, motors and standard cells can be bought from Brown Instrument. Bristol or Stevens Arnold Choppers are better.

They are planning now to make the magnet in 24 sets of sectors, each set having its yoke alternately inside or outside the orbit radius. This will allow the possibility of using particles either inside or outside the circle.