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Quadrupole Design

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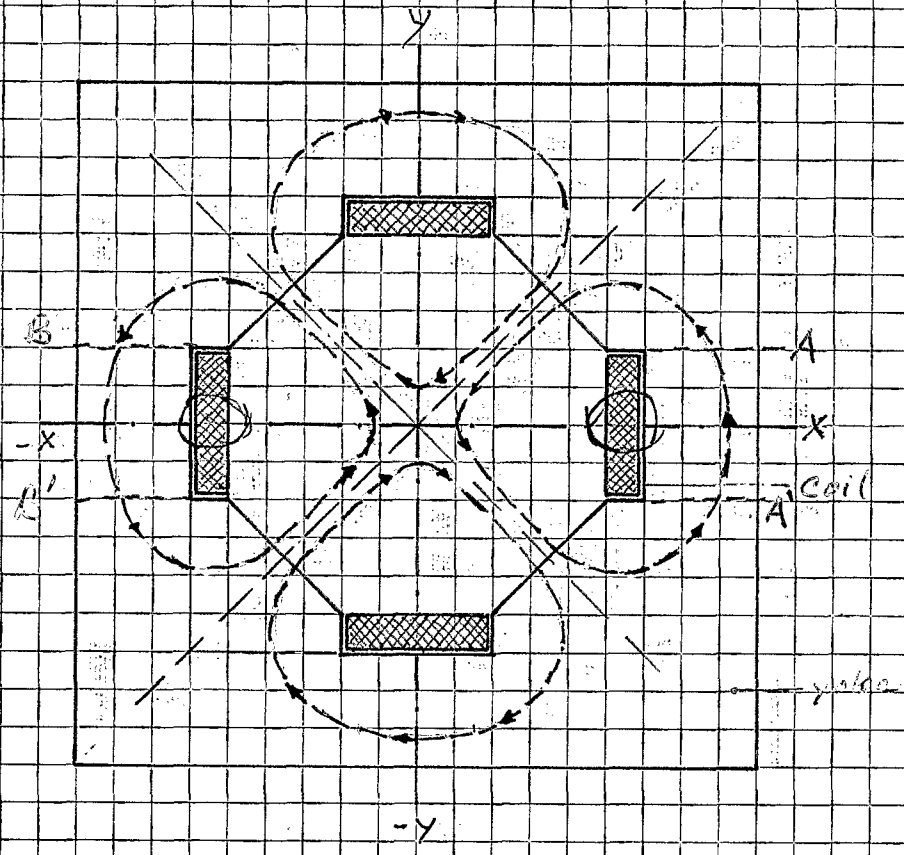
QUADRUPOLE DESIGN

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12/13/84

in Quadrupole design

Consider basic quadrupoles as mechanical layout



There is both magnetic and mechanical quadrupole separation, a few flux lines have been sketched in. It is assumed that the flux through the yoke iron is constant in the horizontal and vertical separating planes $-xoy$. If the iron has sufficiently high μ , this is of little consequence, only a few amp turns are needed to push the flux through and this is very low. If the μ drops, due to iron saturation, the H increases and a non negligible H_y develops in the outer surfaces of the yoke's legs.

From the cross section shown this will appear just such primarily in the vicinity of the horizontal and vertical planes of symmetry.

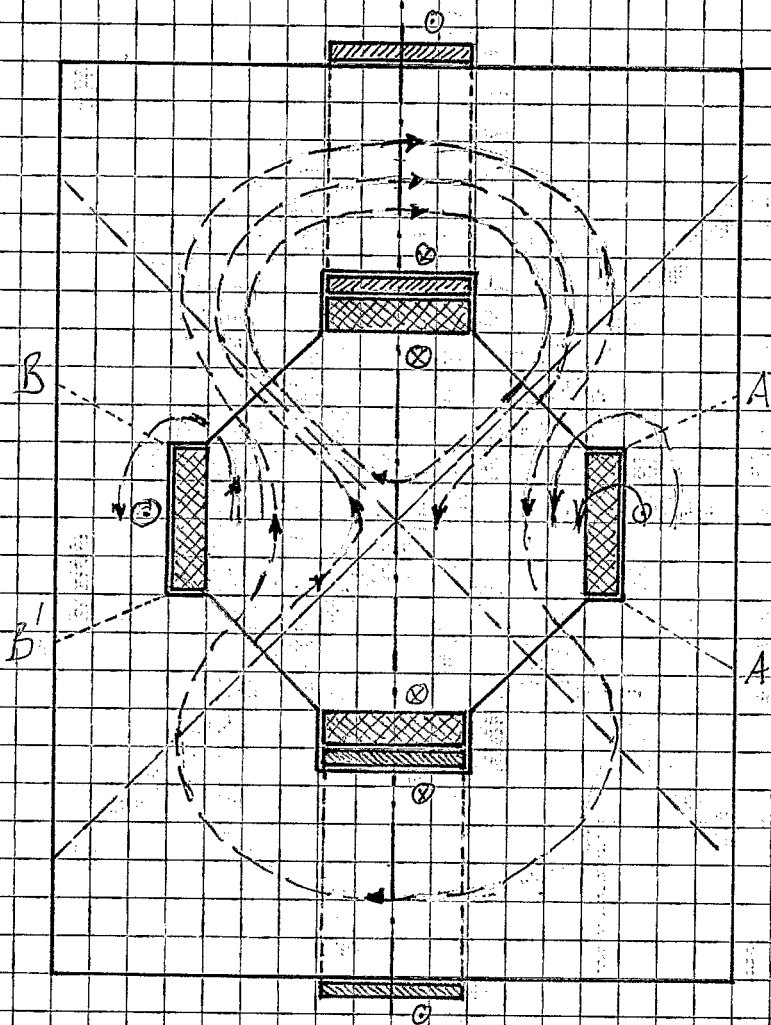
There will be a leakage flux outside the yokes in these regions. This flux tends to pass through nearby, less saturated iron, e.g. through the vertical leg of a companion quadrupole.

The effect can be prevented, or at least reduced by securing the flux through the vertical legs. This can be done by lowering the magnetic potential difference $\int H_{\text{eff}} dl$ between the poles A-A', B-B' to zero, a) by increasing the widths of the horizontal legs, b) by installing additional excitation around these legs. The net result is shown below.

It is clear that some flux can be tolerated in the vertical legs, e.g. F_v to $1T$ perhaps, because up to about 2 gauss/cm it is to hope that H_{eff} on the leg surface is acceptably low.

This is obviously necessary in a quadrupole, since the flux in the vertical legs must change proportionally with the distance to the planes of symmetry.

It is also obvious that the return coils can be very small. Their function is to make the magnetic potential difference between A and B, as well as



that the flux from A' and B' to A and B approximately zero, causing the upper and lower "U's" of the yoke ends of semi-perfect magnetic shorts.

This would be some extra flux is flowing, thus creating a MMF. This MMF can be very small however since it is usually contained by the thickness of the laminated legs, which are not restricted in any way. The position of the two outer coils is usually to compensate for this MMF.