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Quadrupole Design

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QUADRUPOLE DESIGN

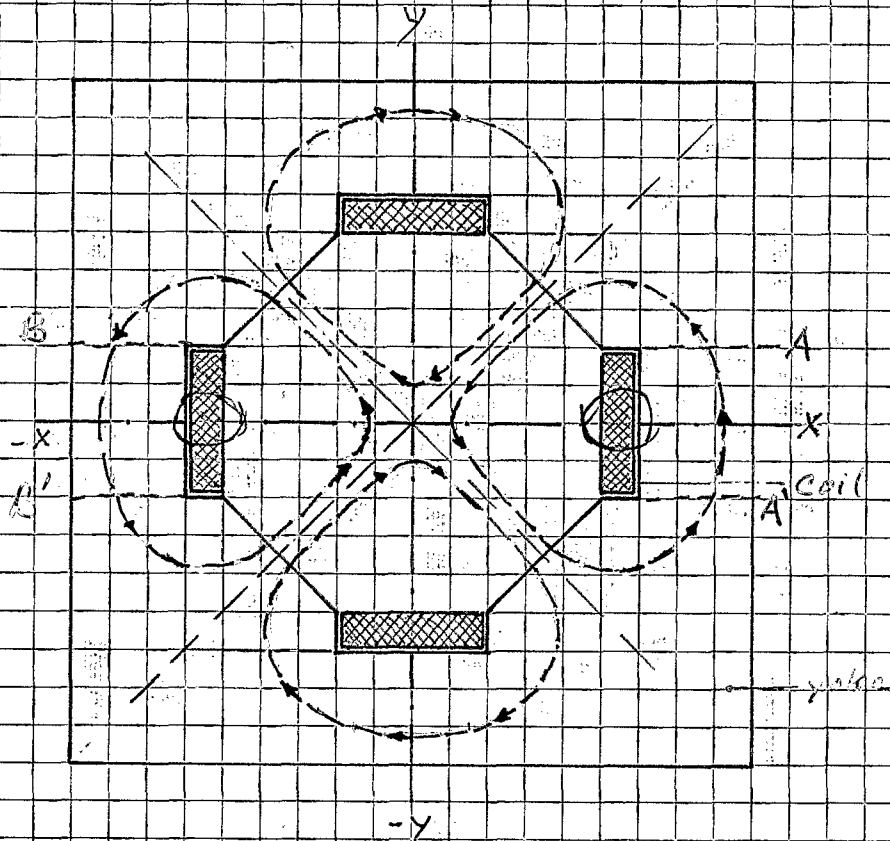
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in Quadrupole design

Consider basic quadrupoles as sketched below



There is both magnetic and mechanical cross-section separating, a few flux lines have been sketched in. It is assumed that the flux through the yoke iron is negligible in the horizontal and vertical separating planes $-xox$, $-yoy$. 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 H is very low. If the μ drops, due to iron saturation, the H increases and H_{iron} becomes a non-negligible H_{coil} density on the outer surfaces of the yoke's legs.

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

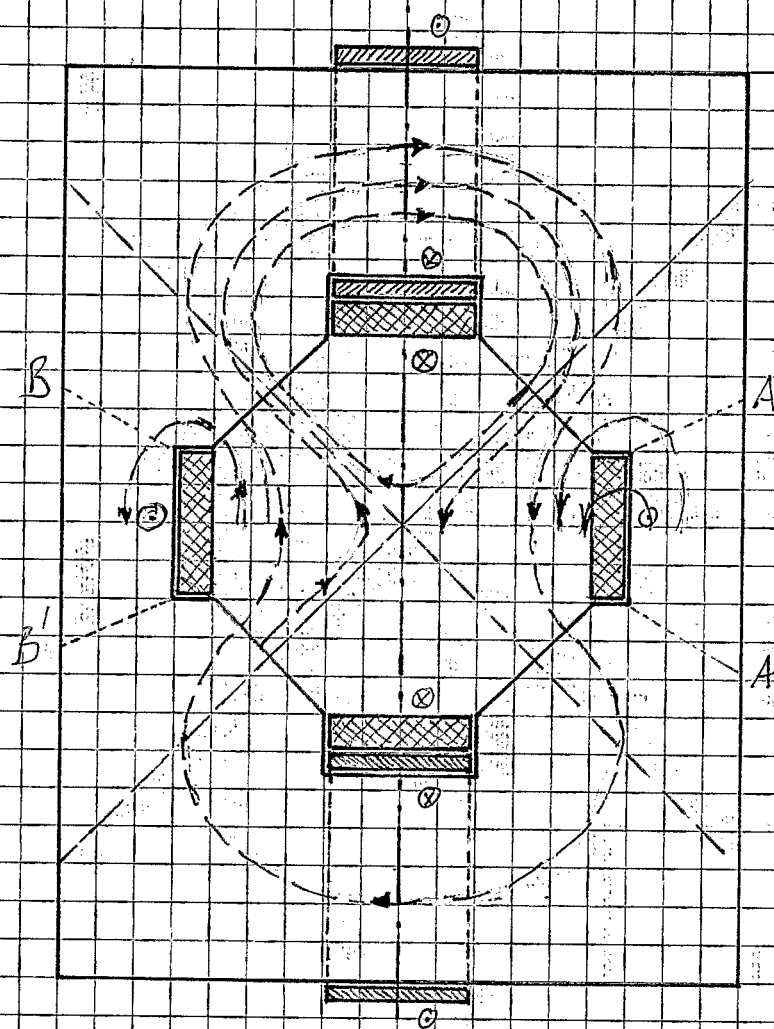
There will be a leakage flux outside the yokes in these regions. This flux tends to flow through nearby, less saturated iron, e.g. through the vertical leg of a companion quadrupole.

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 planes A-A', B-B' to zero, a) by increasing the widths of the horizontal legs, b) by instituting additional excitation around these legs. The last result is shown below:

It is clear that some flux can be tolerated in the vertical legs, e.g. F_z to 15 perhaps, because up to that B value μ_r is so high that H_z on the top 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 outer 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 is approximately zero, assuming the upper and lower "U"s of the yoke ends of semi-perfect magnetic shorts.

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