QUADRUPOLE FOCUSING MAGNET*

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Particle accelerators consume enormous amounts of electrical energy. A very large fraction of this power is dissipated in the windings of the magnets used to guide and focus the primary beam during acceleration and in the primary and secondary beam lines which transport protons, electrons, muons, π mesons, and K mesons after acceleration. The magnets in beam lines are usually dc devices and their capital cost is a large percentage of the installation cost. Because these magnets operate at essentially fixed fields they are ideal candidates for superconduting materials. Such magnets provide the means for obtaining high fields and field gradients in small volumes with low power demands. Operating costs for superconducting magnets may be as much as a factor of ten less than for conventional, copper conductor, iron yoke magnets. The associated equipment includes Dewars, power supplies, and helium refrigerators. These are of such a nature and size that their physical space requirements and connecting utilities are modest and can be moved with ease compared to the bulky conventional magnets.

Because of the possible savings and convenience some portions of the LAMPF experimental area beam transport systems could use superconducting systems. A superconducting quadrupole doublet has been designed at LASL and is now being constructed. The parameters are listed below. The field gradient, 3 kG/cm, is somewhat higher than will be required for the LAMPF experimental area.

Beam aperture (room temperature)	15 cm diam
Field gradient	3 kG/cm
Effective length	> 30 cm
Doublet focal length for 800 MeV protons	~ 60 cm
Optical alignment capability	± 0.010 in.
Dipole correction	± 0.020 in.

Each quadrupole is to be made of four aluminum bobbin forms which bolt together and are then close to 30 cm o.d. and 20 cm i.d. The forms are of two types and approximate the necessary current-turns density in six graded steps. One of the doublets is stepped with varying radial thickness of windings about a median cylindrical surface whereas the other has windings of uniform radial thickness but varying circumferential dimension with aluminum spacers of different widths. The room temperature duct of the containing Dewar is 15 cm.

Two different types of commercially available superconducting wire will be used. The first is a single, large strand of superconductor in a copper sheath; the second is a recently developed multiple-strand wire consisting of a matrix of 49 small strands of superconductor in copper. The former material has a copper to superconducting ratio of three, the latter four. Both wires are 0.050 in. o.d. with Nomex braid insulation

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with 50% coverage. The multiple-strand wire is expected to have superior performance characteristics, but it is more expensive.

In addition to the quadrupole doublet, superconducting double dipoles will be placed around each quadrupole to make fine adjustments in the beam trajectory. The dipole magnets will be capable of shifting the quadrupole field centerline by about ± 0.020 in. with a maximum field of 600 G.

SUMMARY

Two superconducting quadrupole magnets with correcting dipoles enclosed in a single Dewar to form a focusing doublet, iron magnetic shielding, and liquid helium refrigerator are being designed and constructed for use in the LAMPF facility.

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