A SUPERFERRIC STORAGE RING

Robert Rathbun Wilson

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A storage ring made of conventional iron-copper magnets appears to be considerably more economical than one made entirely of superconductor - at least on the basis of present technology. It turns out though that conventional magnets are still rather large and expensive. If the copper in the coils is kept to a reasonable size, then the operating costs become exorbitant; but if the operating costs are kept down, then the cost of the copper necessary to do this becomes excessive. Replacing just the copper of a conventional iron magnet by a superconductor or a cryogenically cooled aluminum conductor would appear to be the answer to this problem. Another difficulty with the conventional magnet is that the aperture must be made larger than necessary in order to get adequate pumping speed; the pumps themselves also represent a major costs. A superconductor right in the vacuum system will automatically give cryogenic pumping and hence will solve much of the vacuum problem.

Let us first consider the superconductor-iron (superferric) magnet. The idea is to make the cross section of the coil structure as small as possible so that it will look more like a transfer tube than a piece of apparatus in helium bath. Figure 1 indicates how a superferric bending magnet might be constructed. The magnets are to be made in an essentially continuous manner so that the coil leads need not be brought in and out of every magnet. Thus the single turn coil is common to all bending and focusing magnets and all would be connected in series.

The magnets could be made from solid steel billets about six feet in length. If they are spaced an inch or so apart, then this space between magnets could be used to support the rigid cold center structure. Super-insulation or a heat shield at liquid nitrogen temperature can be interposed between the cold structure and the warm magnet wall. One must not fall into the temptation of trying to reduce the heat leak to a minimum, but rather should aim to keep the refrigeration problems within bounds while solving the more serious problems concerning the quality of the magnetic field.

A superferric quadrupole magnet is shown in Figure 2. On one side, it makes use of the same conductor with the same current that is used in a bending magnet. However, on the other side, the current in the bending magnet must be diverted to the top conductor of the quadrupole, back through the side, and then through the bottom conductor as indicated. Since ther will be hundreds of joints in the conductors in order to allow this to be done, it will be necessary to develop a good connection in which the strands of superconductor are in direct contact with superconductor. This can be done in a number of ways, one of which is shown in Figure 3. The length of the quadrupoles is chosen such that the same current can be used in the bending magnets and the quadrupoles. In order to be able to compensate for space charge and to be able to explore various running conditions between resonances of the orbit oscillations, a copper trimmer coil is placed within the quadrupole to give a $\pm 5\%$ variation of the quadrupole strength.

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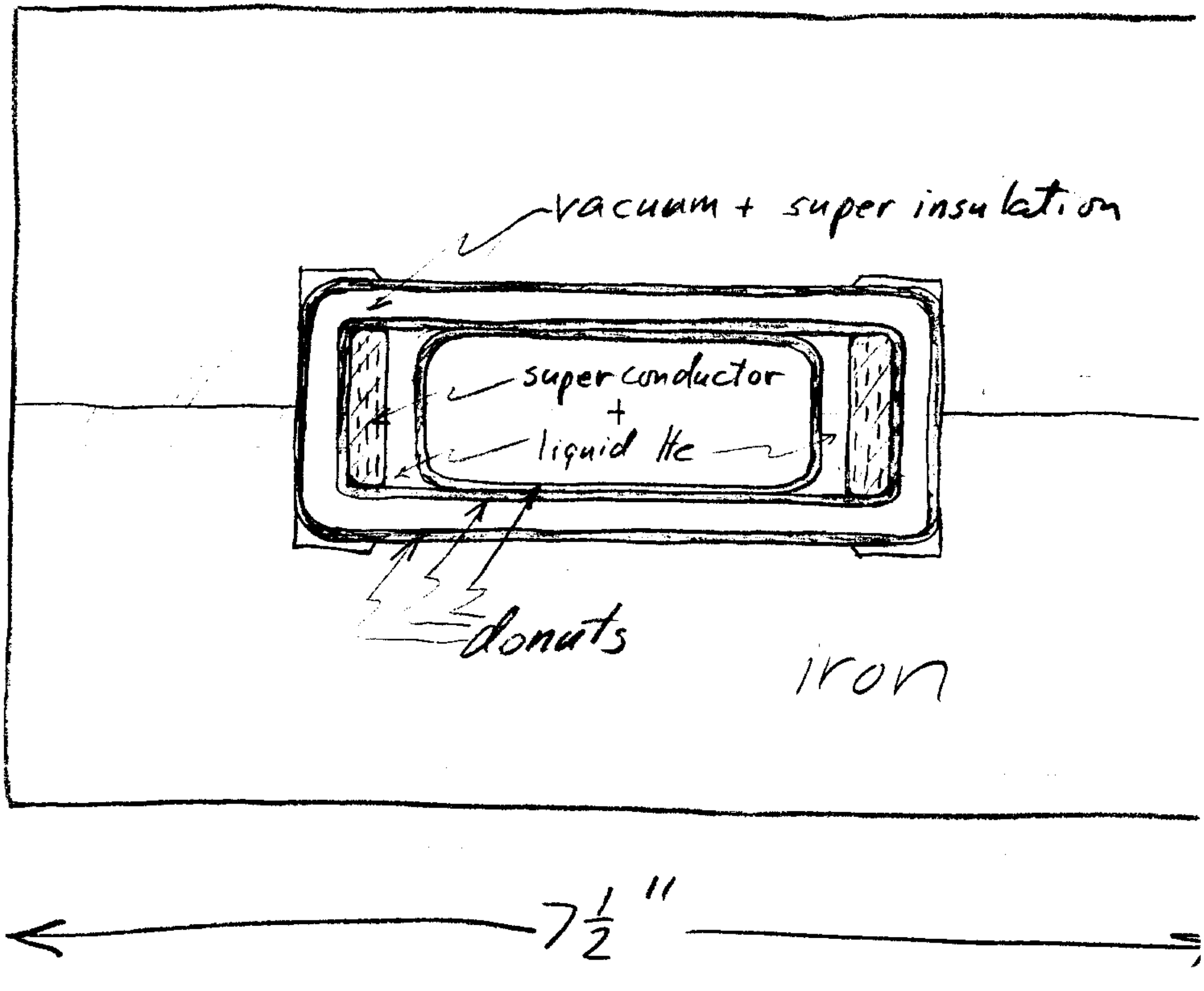
Fig 1



Full Scale

Superferric
Bending Magnet
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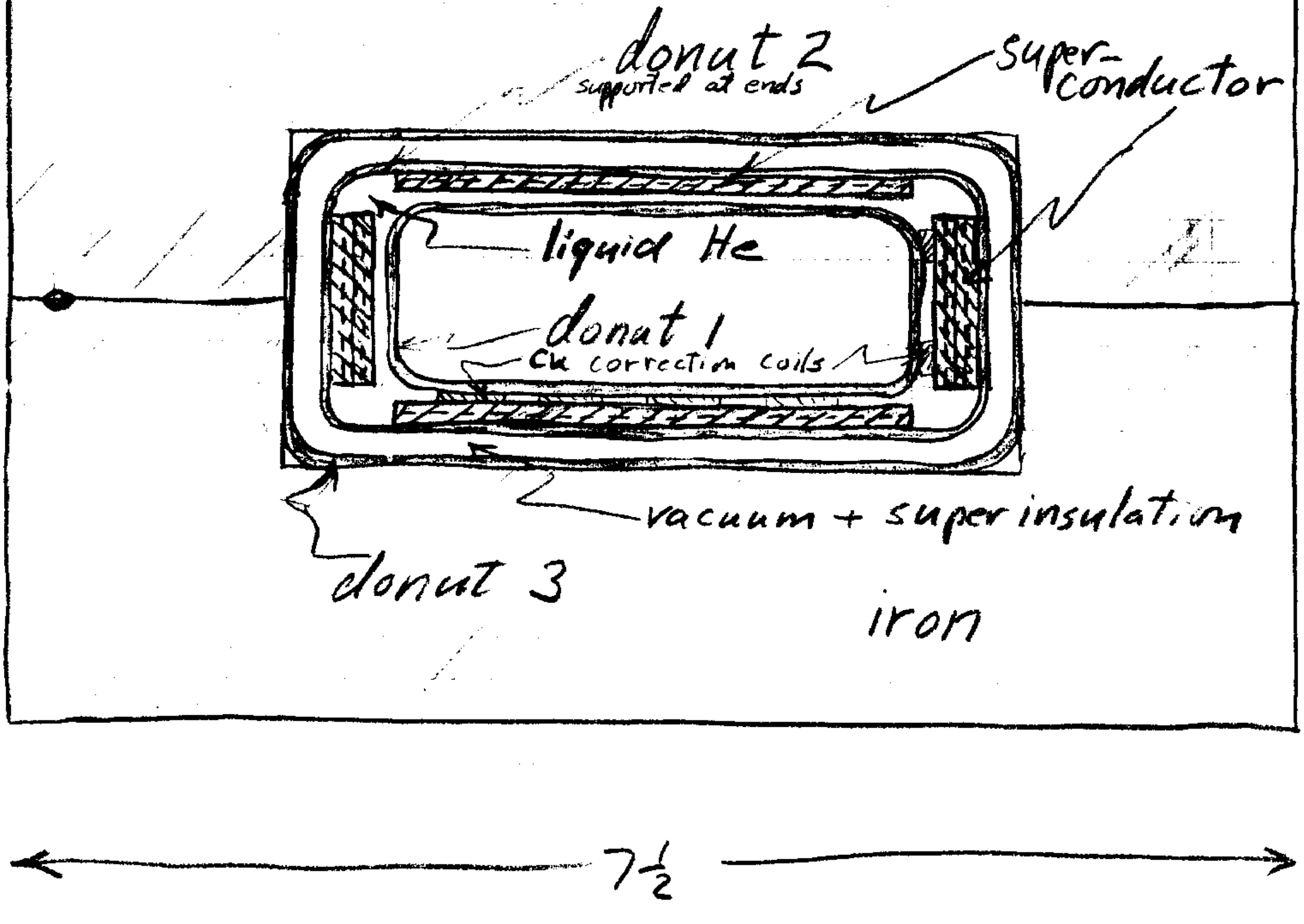
Fig 2



Superferric Quadrupole

Full scale.

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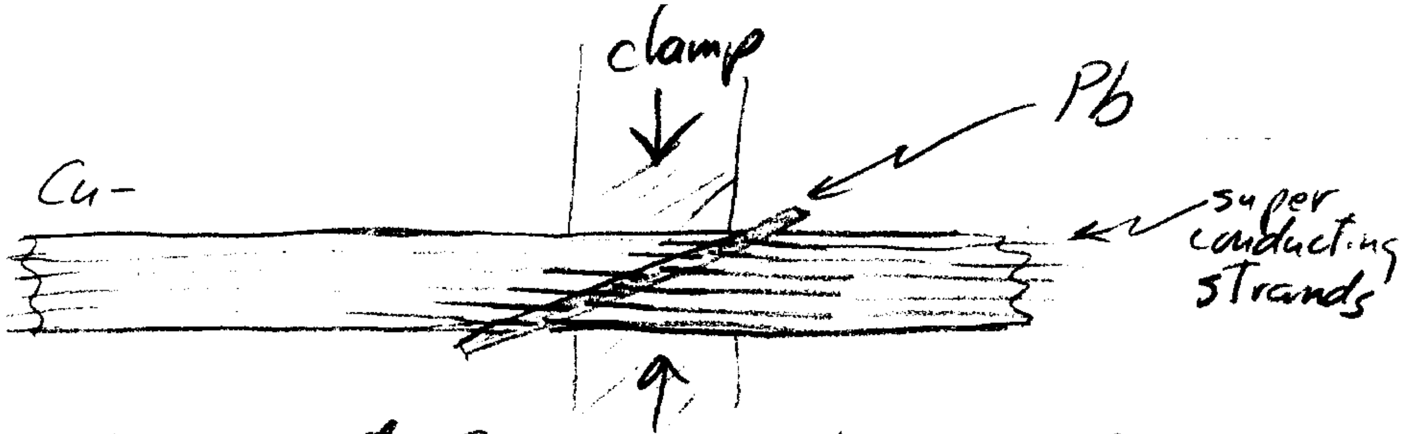
Fig 3



i.e eat Cu away from ends of strands – use Pb gasket the clamp firmly etc.