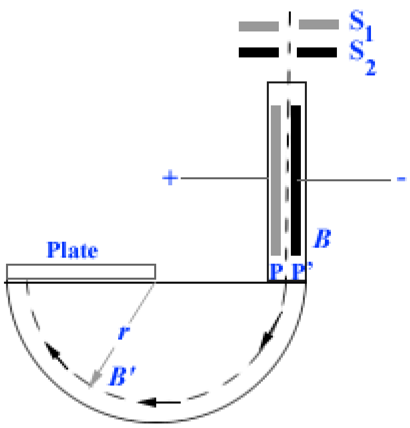
433.

<u>Problem 34.17 (RHK)</u>

Bainbridge's mass spectrometer, shown in the figure, separates ions having the same velocity. The ions, after entering through slits S_1 *and* S_2*, pass through a velocity selector composed of an electric field produced by the charged plates* P *and* P′*, and a magnetic field* $\vec{B}$ *perpendicular to the electric field and the ion path. Those ions that pass undeviated through the crossed* $\vec{E}$ *and* $\vec{B}$ *fields enter into a region where a second magnetic field* $\vec{B}'$ *exists, and are bent into circular paths. A photographic plate registers their arrival. We have to show that* $q/m = E/rBB'$*, where* r *is the radius of the circular orbit.*



Solution:

Condition for velocity selection of charge ions using crossed electric and magnetic fields is that the Lorentz force be zero, i.e.

$$q\vec{E} + q\vec{v} \times \vec{B} = 0,$$

or

$$\left|q\vec{E}\right| = \left|q\vec{v} \times \vec{B}\right|.$$

As $\vec{v}$ and $\vec{B}$ are $\perp$,

$$\left|\vec{v} \times \vec{B}\right| = vB.$$

Therefore, criteria for velocity selection in the first part of the Bainbridge's mass spectrometer is that

$$E = vB.$$

Ions of charge q that come out of the velocity selector with the electric and magnetic fields being E and B, respectively, will have speed

$$v = E/B.$$

These ions after emerging out from the velocity-selector move in a uniform magnetic field $\vec{B}'$, which is perpendicular to $\vec{v}$. The radius r of the circular orbit is determined by the centripetal force provided by the magnetic field on the moving charges,

$$\frac{mv^2}{r} = qvB',$$

or

$$\frac{m}{r} \times \frac{E}{B} = qB',$$

$$\therefore \quad \frac{q}{m} = \frac{E}{rBB'}.$$