The collector **20** is schematically shown as being connected to an amplifier **22** and detector **24** which detects the number of particles which reach the collector **20.** The output of the detector **24** is fed to a suitable recorder **26** for providing a graphic record of the detector output.

Turning further to FIG. 3, there is illustrated a set of taut parallel wires **30** so disposed that their intersections with a transverse plane lie on a circle in that plane. In FIG. 3A, one of these sets of intersections is illustrated where the wires are positioned with equal angles each to the next. The excitation of these wires **30** must be from a divider such as shown in FIGS. 1 and 2 which furnishes potentials corresponding to equal increments of angle in Equation 19 above. In FIG. 3B, an alternative arrangement is illustrated to accommodate a uniform voltage divider by a non-uniform distribution of angular increments between the wires **32**. In this case, rewriting Equation 19,

$$\theta_n = \arc\cos\frac{\phi_n}{\phi_o} \tag{20}$$

with θ_n the angle of the nth wire and ϕ_n representing the nth equal increment of potential from the uniform divider.

The potentials described above and furnished by the example are such as to produce the desired two-dimensional trapping fields with the presumption that the structure is long in the direction of the axis of symmetry.

Three-dimentional traps may also be constructed according to the method of this invention. Such a three-dimensional trap is shown in FIG. 5; therein a set of circular conducting rings **34** are drawn to be contiguous to a pair of facing right circular cones described by the equations:

$$\sqrt{x^2+z^2} = (r_o+\sqrt{2}y) \tag{21}$$

and

$$\sqrt{x^2+z^2} = (r_o-\sqrt{2}y) \tag{22}$$

When these circular conducting rings **34** are uniformly spaced and are excited by an AC and DC source via a linear potential divider as was employed in the example of FIG. 1, the potenial within the structure will be described by:

$$\phi = [U+V\cos\omega t]\frac{x^2+z^2-2y^2}{r_o^2} \tag{23}$$

The equipotentials of this expression are hyperboloids of revolution which will, in fact, provide trapping, given the correct values of U/V, U, V and ω for charged particles of the correct charge-to-mass ratio.

FIG. 4 shows one possible method of distributing conductors to give the required potential distribution within the structure. The electrodes **36** shown in broken section are right circular cylinders whose truncated boundaries **38** are their intersections with the right circular cones of Equations 21 and 22 above. This embodiment is also shown with a charged particle source **40** and collector **42.** In FIG. 5A the equipotential fields generated by such a structure are depicted in what might be a section taken in either the x–y or z–y planes since the structure and resulting equipotentials are symmetrical about the y-axis.

Similarly, FIG. 6 shows an additional configuration, consisting in this case of a set of elliptical rings **44** so disposed as to be contiguous to the surface of the two right elliptical cones defined by:

$$z^2+k^2x^2 = (r_o+y\sqrt{k^2+1})^2 \tag{24}$$

and

$$z^2+k^2x^2 = (r_o-y\sqrt{k^2+1})^2 \tag{25}$$

If these rings be uniformly spaced and excited by an appropriate AC–DC source provided with a uniform voltage divider as was shown with FIG. 1, then the potentials generated within the interior of the structure will be hyperboloidal. They are illustrated in their y–z, x–y, and z–x sections, respectively, in FIGS. 6A, 6B, and 6C. The fields resulting from these potentials will trap charged particles of selected charge-to-mass ratio as is the case in the example of FIG. 5 described above.

It should be specifically mentioned that the configurations of FIGS. 5 and 6 when appropriately excited constitute three-dimensional traps which can contain the motion of selected charged particles in all possible directions.

FIG. 7, analogous to FIG. 4, represents a structure by which the potentials of the example of FIG. 6 may be achieved. The electrodes **46** shown in broken section in FIG. 7 are for this example right elliptical cylinders whose truncated boundaries intersect at equal intervals the right elliptical cones described by Equations 24 and 25. This embodiment is also shown with a charged particle source **48** and collector **50**. A set of conducting leads **52** are also shown for connecting the electrodes **46** to a suitable source of potentials, as illustrated in FIGS. 1 and 2, for example.

It will, of course, be apparent that the bounding edges **54** of the elliptical cylinders **46** will act to create field distributions within the trapping field region in substantially the same manner that an actual set of ring electrodes would. The suggested choice of conductive cylinders is obviously made for reasons of physical rigidity and support. It should be quite clear, however, that many other means of support may be chosen.

After having read the above disclosure it will become apparent that many alterations and modifications may be made to the disclosed apparatus without departing from the invention. It is therefore to be understood that this description is for purposes of illustration only and is in no manner intended to be limited in any way. I intend that the appended claims be interpreted as covering all modifications which fall within the true spirit and scope of my invention.

I claim:

1. Charged particle trapping means for establishing a potential distribution about an axis such that charged particles within a given range of mass-to-charge ratios will have stable motion within said potential distribution and particles having mass-to-charge ratios outside said given range will experience instability in said potential distribution and will be rejected, said trapping means comprising:

- an array of conducting elements substantially symmetrically disposed about said axis and including at least two conducting portions in each quadrant spaced from said axis,
- potential supply means for providing an electrical potential having both AC and DC components,
- potential distribution means coupling said supply means to the respective conducting elements for establishing on the different ones of said conducting elements selected different potentials such that the distribution of said selected different potentials in each quadrant around said axis is the mirror image of the distribution in the adjacent quadrant.

2. Charged particle trapping means as recited in claim 1 wherein said conducting elements are long straight conductors disposed parallel to said axis and spaced around said axis such that the distance separating adjacent conductors is small as compared with a transverse dimension between conductors lying in a plane including said axis.

3. Charged particle trapping means as recited in claim 2 wherein the locus of the intersections of said conductors with a plane transverse to said axis describes a parallelogram.

4. Charged particle trapping means as recited in claim