perpendicular to the equipotential surfaces. Here, we address the focussing of ion beams in gases using concave electric fields as hyperbolic field focussing. This type of focussing was used in mobility cells as taught by Thekkadath in U.S. Pat. No. 5,189,301 by using a cup shaped electrode. Blanchard, U.S. Pat. No. 4,855,595 used also a hyperbolic field focussing method with time varying fields. **FIG. 2**(*a*) illustrates a configuration for using hyperbolic field focusing similar to the one claimed by Thekkadath. A fixed, single cup shaped electrode (**20**) generates a hyperbolic-like field close to the center axis. Ions are sourced at (**5**) and sampled at aperture (**24**). The field lines of such a configuration and the simulated path of an ion in this field are illustrated in **FIG. 3**. The salient feature of the field of **FIG. 3** is that is everywhere both nonlinear and asymmetrical. The distortions from linearity extend in one direction only. Importantly, in the prior art disclosing hyperbolic fields, there are no discrete regions of one or more distinct sub-fields of any kind (i.e., linear fields, non-linear/ symmetric fields, or different non-linear/asymmetric fields) within the drift cell. The fields are uniform within the drift cell; they are everywhere hyperbolic within the drift cell; there are no discrete regions of having different resultant fields. Referring back to the electrode configuration of **FIG. 2**(*a*) that is responsible for the field lines of **FIG. 3**, it should be noted that although the cup-shaped geometry is symmetrical, it is arranged (i.e., juxtaposed) around the drift cell in a asymmetrical fashion in that the electrode structure does not extend to the axis defining the aperture plate. In general, a source of asymmetry in the field-generating component (electrode) is required. This can come from the configuration of one or more electrodes with respect to the drift cell and/or to one another (e.g., asymmetrically arranged electrode(s); in which the component electrode(s) may have either individual symmetry or asymmetry). It may also be introduced from the conformation of the individual electrodes in a series (e.g., a symmetrical arrangement of electrodes having individual asymmetry, or an asymmetrical arrangement of individually symmetric electrodes, or some combination thereof). Other variations are possible while still achieving a hyperbolic field. The general requirement is a fixed configuration and conformation of electrode(s) about the drift tube such that only one resultant field in the drift tube results, and the fixed configuration and conformation must somewhere contain an inherent asymmetry.

Periodic Field Focusing

[0081] The focusing of ion beams in gases with periodic fields is described in more detail in a patent application simultaneously filed with this one, having Ser. No. _____ and incorporated by reference herein. **FIG. 2**(*b*) illustrates a mobility drift cell with periodic field focussing taught in said reference. Ions are sourced at **5** and migrate in the drift tube under the influence of a field created by ring electrodes **10** and are sampled at aperture **24**. In the embodiment of **FIG. 2**(*b*) and external excitation source **6** is used for ionization. The electric field of such a configuration and the path of an ion in this field is illustrated in **FIG. 4**. The basic functioning principle is as follows. Off-axis ions feel a periodically changing electric field with focusing and defocusing properties. After drifting in a focusing portion of the field, the ion will enter a defocusing portion of the field. However, since the ions will enter the defocusing field at a distance closer to the axis as it entered the focusing field, the defocusing effect will be smaller than the focusing effect previously experienced. Hence, during the path of the ion in the device of **FIG. 2**(*b*), the focusing properties will dominate and compensate the defocusing effects of the diffusion.

Embodiments with Combined Periodic and Hyperbolic Focusing Fields and Novel (Purely) Hyperbolic Focusing Fields

[0082] We found that combining and superimposing both methods yields the best results, according to our simulations. Our embodiments allow building mobility drift cells having the optimum trade-off between mobility resolving power and ion beam focusing. For example, in a Mobility-MS with limited pumping speed, the cross section of the ion transmission channel from the mobility section to the MS has to be reduced in order to maintain the pressure differentials. In order to maintain acceptable sensitivity, it may be necessary to increase ion focusing in the mobility cell, trading off some of the mobility resolving power. Our simulations show that superimposing hyperbolic field focussing and periodic field focussing helps to minimize the trade off. **FIG. 5** illustrates the field lines in the drift cell for a periodic hyperbolic field instrument.

[0083] Cone shaped electrodes as in **FIG. 6**(*a*) allow for a maximum portion of hyperbolic focussing in the superposition of the to focussing methods. A series of cone shaped electrodes **11** form a drift tube **10** which terminates at ion aperture **24**. This yields good properties but the electrodes are rather expensive to produce. **FIG. 6**(*b*) shows an embodiment with the same ion optical properties but having electrodes **10** that are isolated from each other with a foil or with a thin insulating material **11** that can at the same time also serve as the sealing the interior of the mobility drift cell from the exterior region. The thin insulating materials may be, for example, kapton film or teflon sheets. Such sealing is often required in order to maintain pressure difference or in order to maintain the gas purity in the interior of the cell. Ions are sampled at aperture **25**.

[0084] A simpler and less expensive embodiment is using beveled thick plate electrodes resulting in cone shaped holes along the spectrometer axis is shown in **FIG. 7**. The cone angles angle in **FIG. 7** are approximately 90 degrees, but changing this angle allows for adjusting the portion of periodic field focusing and hyperbolic field focusing. In the extreme case of a cone angle of 0 degrees, one would obtain the embodiment for pure periodic field focussing described by Gillig.

[0085] **FIG. 8**(*a*) teaches an embodiment which uses an even more simple geometry with thin electrode plates **10**. Pairs of the plates are electrically connected **17** by resistors **16** which determine the potential of each pair, allowing for the use of unequal potential differences between electrodes. The two electrodes forming one pair preferably have an unequal hole diameter. The difference in this diameter determines the portion of periodic field focusing and hyperbolic field focusing. In one extreme, when the hole diameters are equal, one obtains pure periodic field focussing. Alternatively, electrode assemblies having unequal spacing between individual electrodes may be used for the same effect.

[0086] **FIG. 8**(*b*) teaches an embodiment in which the holes of each pair are equal, but instead of shortening the