metrical. The apertured diaphragms **2**, **3** and **4** respectively correspond to the apertured diaphragms R_2, R_3 and R_4 with aperture radii r_2, r_3, and r_4 as referenced above.

[0042] Ions having high mobilities that push back against the supersonic gas jet by the field in front of the apertured diaphragm **3** are in a slightly defocusing field and therefore exit the supersonic gas jet in a lateral direction. Care should be taken that these ions do not reach the ion detector by, for example, extending the apertured diaphragm **3** radially outward to the chamber walls. Most of these ions are destroyed outside the jet at the apertured diaphragm **2**, which is at an ion-attracting potential.

[0043] The ion trajectories are illustrated in FIG. **2**A in such a manner that no losses occur as a result of the ions prematurely leaving the supersonic jet. The trajectories, however, do not necessarily apply to all ions in the jet. For a qualitative analysis, the losses are acceptable. For a quantitative analysis, however, the losses are unacceptable. Referring to FIG. **10**, a short quadrupole rod system operated at RF may be inserted between the Laval nozzle plate **1** and the first apertured diaphragm **2** to drive ions as efficiently as possible into and along the axis of the supersonic jet. The trajectories **6** of the ions in the supersonic gas jet **7** are focused into the axis of the supersonic gas jet **7** by the RF quadrupole rod system **50**. In some embodiments, the quadrupole rod system **50** has a length of approximately two centimeters and is operated with a frequency of approximately two megahertz. Under these conditions, the ions experience approximately 50 periods of the RF voltage, which is in general sufficient for focusing.

[0044] The potential profile P through the axis of the arrangement in FIG. **2**A is shown in FIG. **2**B. By differentiating the potential profile, the profile of the opposing electric field E is obtained as shown in FIG. **2**C, which has a peak in the apertured diaphragm **3** and has a uniform height across the apertured diaphragm.

[0045] The apparatus in FIG. **2**A can be included in a complete mobility spectrometer. Referring to FIG. **3**, for example, ions from an ion cloud **12** at atmospheric pressure are guided along the ion trajectories to the Laval nozzle in wall **1**. The Laval nozzle is therefore designed to accommodate (i) atmospheric pressure at the entrance and (ii) vacuum pressure of, for example, a few hectopascals at the exit. The ions with sufficiently low mobility that remain after passing over the field maximum are driven out of the supersonic gas jet by an electrode arrangement **8** and sent via an ion funnel **9** as an ion beam **14** to an ion detector **15**. To prevent the gas from the supersonic gas jet from burdening a vacuum chamber **26**, the supersonic gas jet, which has been freed of ions, is directed through a vacuum chamber **27** into a vacuum chamber **28**, where it is refracted by impact. The gas thus achieves a higher pressure and can be pumped off by a pump **18** such as, but not limited to, a forepump.

[0046] In some embodiments, the Laval nozzle can be operated, for example, at pressures of a few hectopascal or kilopascal. Referring to FIG. **4**, a known electrospray ion source **20** is shown with a spray capillary **21**, a feed **22** for heatable curtain gas and an inlet capillary **23**. The diffuse outflow **24** from the inlet capillary **23** generates a pressure in the ion funnel **25** that operates the Laval nozzle in the wall **1**. When the inlet capillary **23** is properly dimensioned, the pressure generated by the inlet capillary **23** can be a few kilopascal. The gas is initially cooled by adiabatic expansion in the input capillary **23**. The cooled gas enters, as diffuse gas jet **24**, into the chamber **26** with the ion funnel **25**. Notably, the temperature of the gas is largely restored by gas friction. When an ambient temperature of approximately 293 Kelvin again prevails in the ion funnel **25**, for example, the supersonic gas jet **7** can achieve a maximum velocity of 792 meters per second. When the restored temperature T_0 of the gas in the ion funnel **25** is lower than 293 Kelvin, the maximum velocity is smaller by the root of the ratio of the temperatures. The supersonic gas jet **7** is guided into a special pump chamber **28**, as indicated above, from where its gas can be easily pumped off by a pump **18**. A low pressure therefore can be maintained in the vacuum chamber **17**, where the mobility separation takes place, such that the supersonic jet **7** is not hindered by the ambient gas.

[0047] Referring to FIG. **9**, an outflow diagram is shown for a compressible gas (e.g., air) flowing from a high pressure region, with pressure p_0, density ρ_0 and temperature T_0, to a low pressure region. The local pressure p/p_0, local density ρ/ρ_0 and local temperature T/T_0 are plotted against the relative gas velocity ω. The relative gas velocity ω is equal to the local gas velocity w divided by the local speed of sound a* in the narrowest cross-section of the Laval nozzle ($\omega=w/a^*$). The curve of the flow density $\psi=\rho\times w$ is related to the flow density ψ^* in the narrowest cross-section. For the outflow of air, a maximum velocity of the supersonic gas jet w_{max} is equal to approximately 2.4368 times the local speed of sound a*. The local speed of sound a* is equal to approximately 91.19 percent of the speed of sound in the gas in front of the Laval nozzle (i.e., at T_0). For outflowing air under standard conditions (e.g., 20° Celsius) the maximum velocity of the molecules of the supersonic gas jet is approximately 792 meters per second. For the outflow from a region of lower pressure it depends on the temperature T_0 of the lower pressure region, because the speed of sound is independent of the pressure, but proportional to the square root of the temperature.

[0048] The shape of a Laval nozzle can be optimized using, for example, the known aforesaid "method of characteristics". The Laval nozzle is substantially optimized for ambient pressure at the exit, the most favorable supersonic gas jet being generated when the pressure in the emerging supersonic gas jet is, for example, exactly equal to the ambient pressure. For a Laval nozzle operated at atmospheric pressure, as shown in FIG. **3**, a key factor is the ratio of the diameter d_a of the exit aperture to the diameter d_e in the narrowest cross-section. The flow density curve in FIG. **9** shows that for an ambient pressure of one hectopascal, a diameter ratio d_a/d_e of approximately 4.5:1 is advantageous. For a Laval nozzle measuring 0.5 millimeters at the narrowest cross-section, which generates an inflow of approximately 3.7 liters per minute, an exit aperture of approximately 2.5 millimeters diameter can be used to produce a supersonic gas jet having a 2.5 millimeter diameter. For Laval nozzles operated at far lower pressures different conditions may apply.

[0049] Mobility spectra is measured in the arrangements shown in FIGS. **3** and **4** by continuously or incrementally varying the potential difference $V=(U_4-U_2)$, and with it the maximum of the axial field strength, rather than using field barriers kept on constant height. Given a substantially constant ion current from an ion source, therefore, more and more (or if the field barrier is lowered, fewer and fewer) ion species are filtered out at the field barrier due to their specific mobility. The ion current is thus measured in step **106** which forms the integral over the mobility spectrum of the ions. Differentiating the integral curves gives the mobility spectrum in step **108**. FIG. **6** graphically illustrates the total ion current $I_{tot}=f(V)$ (the top curve) and the mobility spectrum $-dI_{tot}/dV=f'(V)$ (the bottom curve) obtained by differentiating with respect to V.