

4. One large resonator of diameter 0.48 m and of length varying from 0.30 m to 2.30 m.

5. Eighteen forks for notes from  $c_7$  to  $f_9 = 43,390.6$  v.s.

6. Fifteen forks for notes from  $g_9$  to 180,000 v.s.

Under the head of pitch come two very difficult questions relating to the audibility of very low or very high sounds. With regard to the former, Helmholtz has shown that, if the vibrations are very slow, and do not follow the pendular law, (the fundamental being thus accompanied by a series of harmonics) the fundamental may be quite inaudible, whilst the harmonic is heard distinctly. In such a case the harmonic is often mistaken for the fundamental. On the other hand, if we employ large tuning-forks, vibrating rods, or the wave-siren for the purpose of obtaining pendular vibrations, we are still met with the difficulty of determining accurately the limit of audibility, owing to the fact that it not only depends on the intensity of the vibrations, but varies from one observer to another. In general it may be stated that it requires from 60 to 80 v.s. to produce a sound perfectly continuous and possessing a musical character. In using very powerful high forks to produce beats, which were gradually diminished in number, Kœnig found that the sensation of a continuous low sound ceased when their number did not exceed 26.

As to the high notes above  $C_7 = 8192$ , the amplitudes of the vibrations are generally so small, that the ordinary methods no longer serve to determine the pitch. For this reason it was at first the practice to tune forks above  $C_7$  by means of the ear. The high forks constructed by Marloye and presented in 1848 by Depretz to the Academy of Sciences at Paris were constructed in this way. In 1858, however, Kœnig showed that even in the upper half of the octave  $c_6-c_7$ , the best musicians ceased to judge the intervals accurately, a fact which seemed to show that it was extremely unlikely that forks giving notes two octaves higher could be tuned accurately by the ear. For this reason Kœnig effected the tuning of very high forks by means of the sounds resulting from their beats. The first series of forks tuned in this way were made by Kœnig in 1876. A set of similar forks constructed about the same time by Preyer, and going, as he alleged, as high as  $c_{10}$ , were shown by Melde in 1894 to be greatly out of tune, the intervals being wrong by as much as a third, and even an octave. In 1897 Melde's results were confirmed by Stumpf and Meyer.

In 1899 Kœnig published his researches on very high notes. In this memoir, after showing the exactness of the tuning attained by the sounds of beats in forks between  $c_7$  and  $f_9$ , he proceeds to state that, by means of Kundt's method of using light powders, he had con-