sisted in vibrations of some kind; but to determine the nature and laws of these vibrations, and to reconcile them with mechanical principles, was far from easy. The leading facts which had been noticed were, that the note of a pipe was proportional to its length, and that a flute and similar instruments might be made to produce some of the acute harmonics, as well as the genuine note. It had further been noticed,[1] that pipes closed at the end, instead of giving the series of harmonics 1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, &c., would give only those notes which answer to the odd numbers 1, $\frac{1}{3}$, $\frac{1}{5}$, &c. In this problem also, Newton[2] made the first step to the solution. At the end of the propositions respecting the velocity of sound, of which we have spoken, he noticed that it appeared by taking Mersenne's or Sauveur's determination of the number of vibrations corresponding to a given note, that the pulse of air runs over twice the length of the pipe in the time of each vibration. He does not follow out this observation, but it obviously points to the theory, that the sound of a pipe consists of pulses which travel back and forwards along its length, and are kept in motion by the breath of the player. This supposition would account for the observed dependence of the note on the length of the pipe. The subject does not appear to have been again taken up in a theoretical way till about 1760; when Lagrange in the second volume of the *Turin Memoirs*, and D. Bernoulli in the *Memoirs of the French Academy* for 1762, published important essays, in which some of the leading facts were satisfactorily explained, and which may therefore be considered as the principal solutions of the problem.

In these solutions there was necessarily something hypothetical. In the case of vibrating strings, as we have seen, the Form of the vibrating curve was guessed at only, but the existence and position of the Nodes could be rendered visible to the eye. In the vibrations of air, we cannot see either the places of nodes, or the mode of vibration; but several of the results are independent of these circumstances. Thus both of the solutions explain the fact, that a tube closed at one end is in unison with an open tube of double the length; and, by supposing nodes to occur, they account for the existence of the odd series of harmonics alone, 1, 3, 5, in closed tubes, while the whole series, 1, 2, 3, 4, 5, &c., occurs in open ones. Both views of the nature of the vibration appear to be nearly the same; though Lagrange's is expressed with an analytical generality which renders it obscure, and Bernoulli has perhaps

[1] D. Bernoulli, *Berlin. Mem.* 1753, p. 150. [2] *Princip.* Schol. Prop. 50.