> pendulum in opposite swings were so much in agreement that they never receded the least bit from each other and the sound of each was always heard simultaneously. Further, if this agreement was disturbed by some interference, it reestablished itself in a short time. For a long time I was amazed at this unexpected result, but after a careful examination finally found that the cause of this is due to the motion of the beam, even though this is hardly perceptible. The cause is that the oscillations of the pendula, in proportion to their weight, communicate some motion to the clocks. This motion, impressed onto the beam, necessarily has the effect of making the pendula come to a state of exactly contrary swings if it happened that they moved otherwise at first, and from this finally the motion of the beam completely ceases. But this cause is not sufficiently powerful unless the opposite motions of the clocks are exactly equal and uniform.

The first mention of this discovery can be found in Huygens' letter to his father of 26 February 1665, reprinted in a collection of papers [Huygens 1967a] and reproduced in Appendix A1. According to this letter, the observation of synchronization was made while Huygens was sick and stayed in bed for a couple of days watching two clocks hanging on a wall (Fig. 1.2). Interestingly, in describing the discovered phenomenon, Huygens wrote about "*sympathy of two clocks*" (*le phénoméne de la sympathie, sympathie des horloges*).

Thus, Huygens had given not only an exact description, but also a brilliant qualitative explanation of this effect of **mutual synchronization**; he correctly understood that the conformity of the rhythms of two clocks had been caused by an imperceptible motion of the beam. In modern terminology this would mean that the clocks were synchronized in anti-phase due to **coupling** through the beam.

In the middle of the nineteenth century, in his famous treatise *The Theory of Sound*, William Strutt (Fig. 1.3) [Lord Rayleigh 1945] described the interesting phenomenon of synchronization in acoustical systems as follows.

> When two organ-pipes of the same pitch stand side by side, complications ensue which not unfrequently give trouble in practice. In extreme cases the pipes may

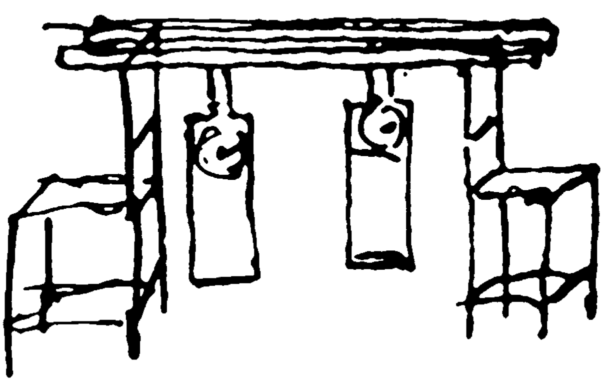

Figure 1.2. Original drawing of Christiaan Huygens illustrating his experiments with two pendulum clocks placed on a common support.