

CHAPTER 2: POWER

Part A

1. INTRODUCTION

Inflection—the encurvation of celestial motion—was a great novelty and a major step towards meeting Galileo’s challenge and establishing celestial mechanics. But it was not enough. For Hooke’s speculations to become a *Programme*, i.e., an outline for research, he had to suggest *a cause* for this encurvation. To complicate matters, the planetary trajectories are not only *curved*—they are *cyclic*. Unlike the effect on the light passing through them of the water in his microscope and the salt water in his tank, the gradual bending of the planetary motions results in continuous, repetitive orbits. Hooke’s hypothesis of the cause of celestial inflection had to allow for that as well.

Hooke was clearly aware of this aspect of his task, and the purpose of the conical pendulum of the 1666 *Address* was precisely

to shew, that *circular* motion is compounded by a direct motion by the tangent, and another endeavour tending to the center. (Birch II, 92. Italics added)

He was also painfully aware of his inability at the time to explain this “endeavour.” “I have often wondered,” he cautiously begins his *Address*, “why the planets should move about the sun.” Unable to support any one answer to his query, he offers two hypothetical ones; the “cause of inflecting a direct motion into a curve may be” either “an unequal density of the medium,” or “an attractive property of the body placed in the center” (*ibid.*, 91. See Chapter 1).

However, the tone of his *Attempt to Prove the Motion of the Earth* in 1674 is markedly different. The original quavering presentation is replaced by the brazen title “a System of the World,” and of the two “likely cause[s] for the performance of this effect,” only one remains. Hooke has managed to dispense with the medium hypothesis altogether; the only candidate for explanation in this later version of the *Programme* is “That all Cœlestial Bodies Whatsoever, have an attraction or gravitating power towards their own Centers, whereby they attract not only their own parts ... but ... also ... all the other Cœlestial Bodies that are within the sphere of their activity” (see Chapter 1).

The last chapter showed that already in the *Address*, Hooke had decided that “attractive property” was the explanation of choice for inflection. In

fact, he never gave any real consideration to any other hypothesis. His early attempts to endow the notion of “attraction or gravitating power” with meaning were, however, unsatisfactory. They were related to his attempts to capture and measure gravitation by means of pendulums, and by the time he gave his *Address*, these efforts had already produced some disappointment (although Hooke did not altogether abandon his pendulum experiments). Eight years later the situation was rather different. At the time he was writing the *Motion of the Earth*, Hooke already had an alternative shaping up; a replacement for the pendulum in its technical as well as theoretical duties. The prospects of constructing “power” as a viable theoretical device were therefore much brighter, and it is this new self-confidence that the “System of the World” reflects.

This was not an entirely new alternative. Hooke based it on the theoretical speculations he had allowed himself while operating his air pump at Boyle’s service back in the late 1650s. Numerous diary entries from the 1670s, as well as his Cutler Lectures—the 1676 *Helioscopes* and 1677 *Lampas*—document Hooke’s construction of the new notion of ‘power’, the notion he would bring to his correspondence with Newton. It took several more years to flesh it out, and the outcome was another Cutlerian Lecture, published in 1678, and bearing Hooke’s ingenious alternative in its title: *De Potentia Restitutiva, Or: Of Spring*.¹

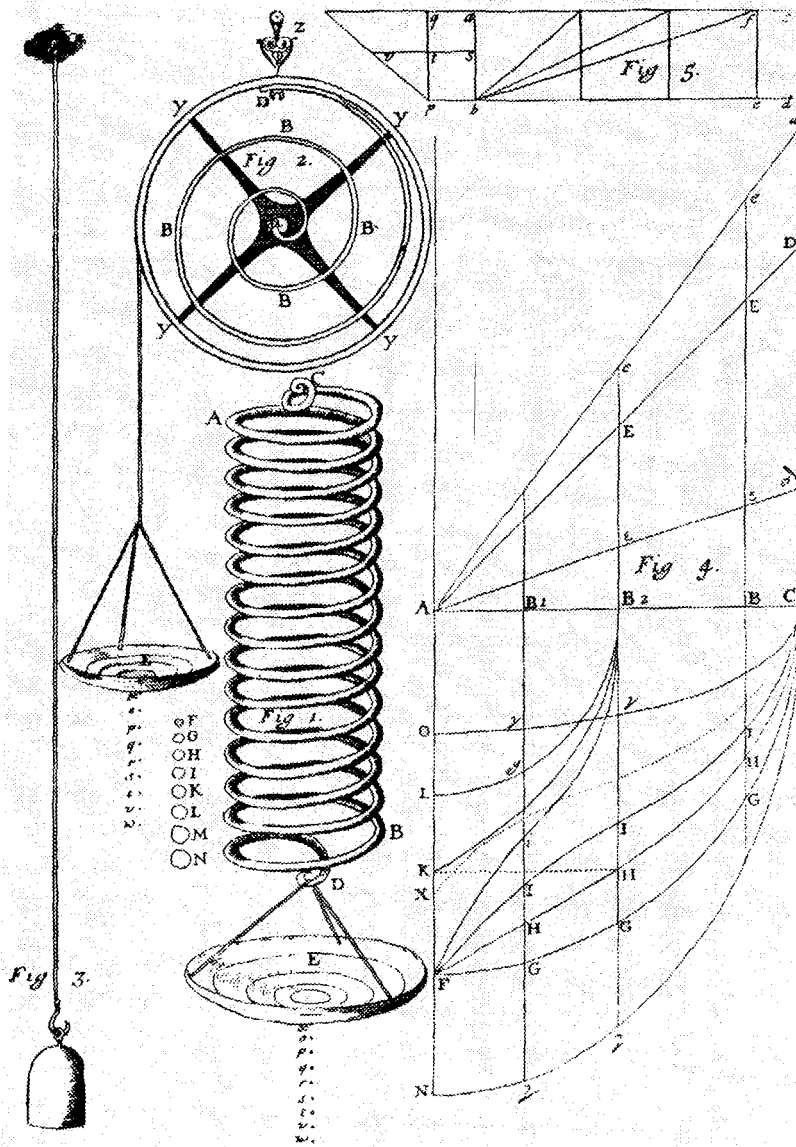


Figure 7: Of Spring—the main diagram (C.L., 332).

2. DE POTENTIA RESTITUTIVA, OR: OF SPRING

2.1. A Theory of Matter and Power²

At the heart of *Of Spring* is an ambitious theory of matter. “The sensible world,” Hooke submits, “consist[s] of body and motion” (*De Potentia*, 7; *C.L.*, 339). These two are inter-translatable, if not outright “one and the same”, as body is “somewhat receptive and communicative of motion” and motion is “power or tendency progressive of Body” (*ibid.*). It is their product—“body” times “motion”—which is the consequential magnitude, “for a little body with great motion is equivalent to a great body with little motion as to all its sensible effects in Nature.” It is not clear whether Hooke is suggesting global conservation of this magnitude³, but he certainly thinks in terms of local conservation: “These two always counterbalance each other in all the effects, appearances, and operations of Nature” (*ibid.*).

Hooke pursues the inter-dependence of matter and motion to an extreme, claiming that real ‘substance’ constitutes only a small part of the bulk of material bodies: “all bodies ... owe the greatest part of their sensible or potential Extension to a Vibrative motion” of their particles. This vibration, he argues, is the “power from within” which “defends” matter: thus according to Hooke, it is motion that causes impenetrability:

To make this the more intelligible, Imagine a very thin plate of Iron, or the like, a foot square, to be moved with a Vibrative motion forwards and backwards ... the Length of a foot with so swift a motion as not to permit any other body to enter into that space within which it Vibrates, this will compose ... a cubick foot of sensible Body (*De Potentia*, 8; *C.L.*, 340)

The idea that the solidity and spatiality of matter are effects of the motion of particles “differs from the common notion of Body” (*ibid.*), Hooke proudly declares. It is an idea Hooke has been most committed to; his earliest version of it had already been published in his unsigned contribution to Boyle’s 1662 *Defence of the Doctrine touching the Spring and Weight of the Air* (Boyle, vol. 1, 118-185)⁴. The precursory version involved “particles of the form of a piece of ribbon” with “innate circular motion” (Boyle, vol. 1, 178-179), while the later version requires only “Vibrative motion forwards and backwards,” and does not assign any particular form to the particles, although Hooke does find a theoretical role for their primary qualities: “Every particle of matter according to its determinate or present Magnitude is receptive to this or that peculiar motion and not other.” Similarly to the way in which the length of the string will determine its oscillation, and thereby its tone, the magnitude of a particle

will determine the amplitude of vibration to which the particle is receptive (*De Potentia*, 8-9; *C.L.*, 340-341)⁵. Surprisingly, Hooke insists that the “Vibrative motion” is *not* “inherent or inseparable from the Particles of body” (*De Potentia*, 8; *C.L.*, 340), which seems to contradict his note concerning the near identity between matter and motion. This could perhaps be interpreted as a gesture towards Boyle, who abhorred Epicureanism and its materialistic implications, and for that reason withdrew from his support of Hooke’s early “vibrative” account of the “spring of air” as formulated in the *Defence*.⁶ In the 1665 *Micrographia*, Hooke was still less restrained, denying “that there is any such thing in Nature, as a body whose particles are at rest” (16).

The other factor determining the particle’s vibration, besides its “Magnitude,” is the balancing vibration of the surrounding particles. These belong, mostly, to the “Heterogeneous fluid medium encompassing the earth” (*De Potentia*, 15; *C.L.*, 347). This “menstruum” is a central constituent of Hooke’s theory:

All bodies whatsoever would be fluid were not for the external Heterogeneous motion of the Ambient.

And all fluid bodies whatsoever would be unbounded, and have their parts fly from each other were it not for some prevailing Heterogeneous motion from without them that drives them more powerfully together. (*De Potentia*, 12; *C.L.*, 344)

Nevertheless, the shape of bodies is not completely dependent on their environment. Reaching back to his very first publication, the *Attempt for the Explication of the Phenomena Observable in an Experiment Published by the Honourable Robert Boyle* (1661), Hooke imports into his theory that a concept he has hardly used since this early pamphlet. The harmonious motion of adjacent particles, he explains, creates ‘congruity’ among them, *viz.*: it “strengthen[s] the common Vibration of them all against the differing Vibrations of the ambient bodies” (*De Potentia*, 9; *C.L.*, 341). Bodies whose particles oscillate harmoniously have a relatively stable shape and volume. These are what are known as “solid bodies” (*De Potentia*, 10; *C.L.*, 342). The particles of “Fluid bulks,” on the other hand, are small and far apart, and are “consequently pervaded by the subtil encompassing Heterogeneous fluid menstruum” (*ibid.*). Thus, they are not congruous—their vibrations are not in harmony, and their dimensions are determined solely by the dynamic equilibrium between the outwards and inwards pressures; between the vibrations of the aggregated particles and those of the surrounding “fluid.”

Hooke’s etudes on the theme of matter-in-motion are no mere flights of

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Gal, O.

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