

SUMMARY OF THE TALK FOR APRIL 2015 SWLP:

'And there is no more Philosophical Twist', but did it give rise to the Scientific Revolution as some Scholars have claimed?

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I would like to present the amazing work of Christiaan Huygens (The Hague 1629- The Hague 1695) as an example of how more modern science was developing in the XVIIth century and how new fields of knowledge sprang from new ideas and experimentation carried out away from the inhibited environment of the universities in the Scientific centres created around Europe. Furthermore, it flourished even more because of the amazing communications between the natural scientists of the time in France, UK, Italy, and The Netherlands. I refer to Christiaan Huygens as a natural scientist against the general description of natural philosopher. Huygens took upon himself to improve and invent instruments that could be used to observe (the air-pump, the microscope, and the telescope), measure (the pendulum clock) or imitate nature (the air-pump).

Huygens was well known before he was invited to join the Court of Louis XIV in 1666, he had been made a member of the Royal Society in London in 1663. He was known for his clocks that he improved constantly and he wanted to promote them and sell them. He developed a new methodology of mechanics to explain the pendulum clock in a geometrical manner instead of the arithmetical way we know now and which developed after Euler a century later. He was also known for his mathematics and he embraced the new philosophies of Descartes and the Atomists and he developed them further when he tried to explain how the universe worked.

Huygens was a type of renaissance man because he did not concentrate in one field of research and that is why he is so appealing as a forerunner of several fields at least in the methodology but above all as a mechanical engineer with a textbook that was taught in universities the *Horologium Oscillatorium*, 1673, and that paved the way for Newton to work out and write his *Principia*.

Huygens knew of Descartes very early in life and from a forward-thinker, his teacher at Leyden, von Schooten who translated and taught Cartesian philosophy against the difficulties of a faculty imbedded in traditional Thomist ideology. To the new thinking inspired by Descartes, Huygens, like some of his contemporaries, added Atomism, Democritus, Epicurus and Lucretius translated by Gassendi, to define some of the observations in the air-pump. Democritus believed that everything was the result of natural laws and like him other Atomists formulated that nature consisted of two main principles: Atoms and void. The air-pump was built to find the void and to explain what would happen in a vacuum.

Two fields of knowledge converge in his work. First of all, the mechanics of the clock with the geometry of movement, rectilinear and circular, and, secondly, the physical phenomena of the air-pump where he defined his theory of the specific matters that made up nature and these he divided according to the different sizes of particles. Each one in turn, made up of smaller and smaller particles: ether, magnetic matter and subtle matter. His work in magnets gave rise to magnet matter which was between ethereal matter (bigger than magnetic matter) and subtle matter that could penetrate everything and was made up of the smallest particles of matter.

Why am I talking about mechanics and physics? The Western world was looking for solutions to the longitude at sea (hence the need for an instrument of precision: the pendulum clock). Huygens was able to improve the pendulum clocks then available to a delay of only one minute a day. Pendulum

clocks were then taken to sea to help to find longitude, before the invention of the chronometer by Harrison the following century.

The experiments on the air-pump showed unexpected results of previously unquestioned phenomena that he could not answer either. The new man-made instruments: the air-pumps created to explain what type of 'matter' kept the universe together and to understand nature produced more questions than answers. Originally the air-pump was designed to find vacuum, an airless space. However, experiments showed that trying to empty an inverted glass of air was more complicated than they had originally thought. The pumps built air-leaked and further improvements to various parts were necessary over time. The three pumps included here show how varied they were but one thing was common to all: experimentation and the search of a vacuum, not only to reproduce natural phenomena but the commercial idea behind inventions so that they could be sold and used by many as Huygens had done with his clock. He actually made patents and tried to sell it through Colbert (a bureaucrat at the Court of Louis XIV) before he was called to work at the Academie des Sciences. Boyle had the drawings made and wrote the instructions on how to reassemble the different parts to make one and sold it in the way we buy our own DIY gadgets and furniture.

Figure 1: Boyle's pump which was available commercially, Huygens started with one.

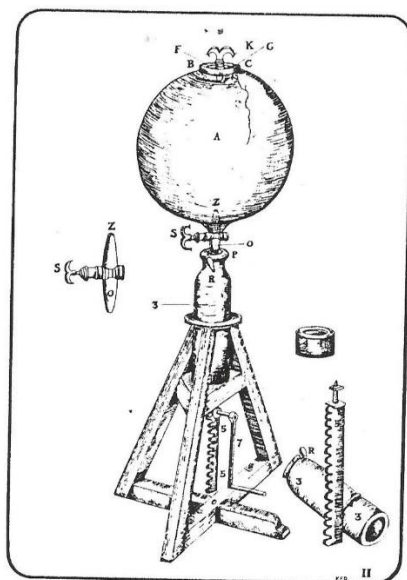
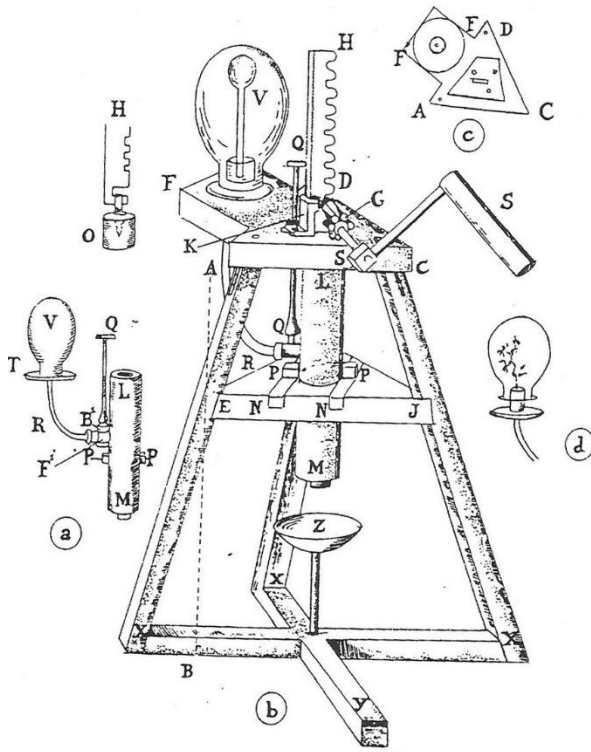


FIGURE 4. Boyle's First Air-Pump, designed by Hooke, from Boyle, *New Experiments Physico-Mechanical* (1660).

- A Glass Receiver, with capacity of 30 wine quarts
- BC Metal cap on lip of receiver
- FG Removable top
- K Stopcock in top
- S Stopcock between receiver and pump
- O Shank connecting receiver and pump
- Z Opening of shank into receiver
- 3 Cylinder of cast brass, 14 inches long, with a bored center, 3 inches in diameter
- P Neck of cylinder, into which stopcock fits
- R Valve, a tapering peg of brass fitted into tapering hole bored in cylinder; here as in Boyle's plate, the taper of the peg is shown incorrectly in the main illustration
- 4 Piston
- 5 Rack

Figure 2: The French Pump

French Pump, Academie Royal Des Sciences
 April-May 1668



VI Figure 2

Huygens improved Boyle's pump but it was still leaking as the experiments of the barometer showed. He invented the barometer when he wanted to observe what would happen to fluids inside a vacuum. The bubbles he saw and which changed as he opened or emptied the glass of air was a key event in his observations. He believed that 'subtle matter' could traverse anything, glass, solids, all the universe.

Figure 3: Huygens' experiment of the void within the void inspired in the Torricellian experiments.

A- Inverted flask
 B Recipient
 C- Water level when air was let in
 D- water level in B in the void.
 Huygens' Experiment
 1661 of the
 Void within the Void

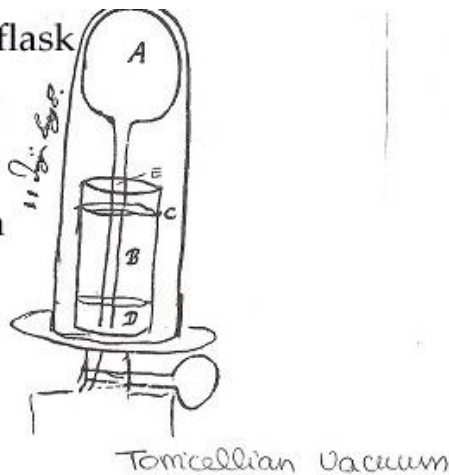


Figure 4: von Guericke's air-pump (1657), The Netherlands.

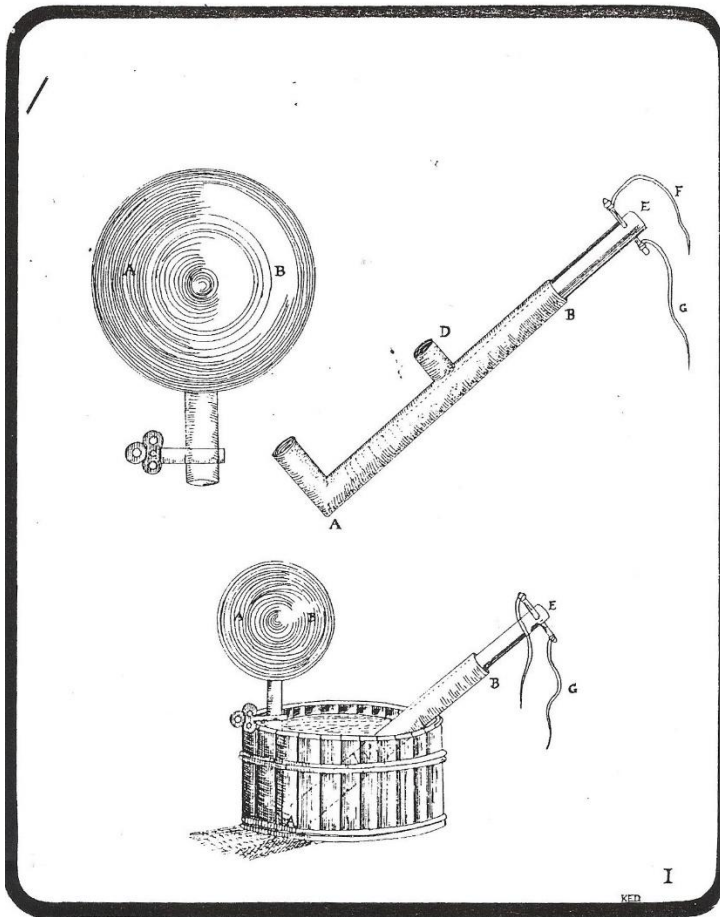


FIGURE 3 - Von Guericke's Air-Pump, from Schott, *Mechanica Hydraulico-Pneumatico* (1657), plate LVI.

- AB Receiver
- ADB Cylinder with valves at A and D
- E Pump, like bicycle pump
- FG Leather thongs used to pull pump out of cylinder

The pump rested in a barrel of water which served to make it air-tight.

Of all the matters Huygens defined subtle matter was quite different from any of his contemporaries because this matter was made up of the smallest particles and penetrated anything including the vacuum hence influencing the experiments he was doing. Huygens explained the new phenomena with the last 'philosophical' discourse he had but he was already moving onto a new field. Who has not heard of black matter?

The New Science emerging outside universities gave rise to several centres of research and investigation. As the air-pumps show scholars exchanged information all throughout Europe and the main centres known to us were the Academie des Science, (Paris), the Royal Academy (London), L'Academia di Cimento (Italy) and in the Netherlands, independent but well connected and in regular communication a good number of natural scientists such as Von Guericke.

Huygens was modern not in the way we understand nowadays but in the way he was viewed then. He pioneered a new way to study nature without the philosophical foundations that had characterized it so far. He broke with the then traditional and Thomist philosophy to develop a new way and using the then modern physics available: starting with some of the Cartesian ideas that brought new questions, the classic translations of Epicurus and Lucretius in Gassendi's works; Democritus and Huygens' own conclusions and newly developed theories. On the one hand, his mechanics were an important new step towards mechanical engineering with his statics and

dynamics which were moving away from metaphysics. On the other hand, he was moving further away from metaphysics and Thomism with new theories of matter and moving quickly from the philosophical Cartesian definition of motion onto a geometrical annotated method. Furthermore, the Cartesian whirlpools that defined gravity, Huygens perceived as particles similar to atoms that moved in a random manner. Subtle matter was Huygens' discovery. It traversed everything, filled up the space and held the planets together and it was made up of the smallest of all particles in existence. Does the concept of 'dark matter' in the universe sound familiar?

Some references:

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