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OTTO VON GUERICKE: A NEGLECTED GENIUS.

BY

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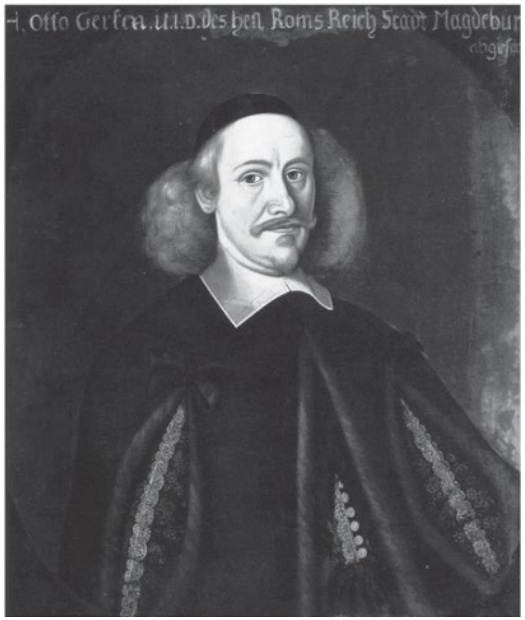

Samapti Mondal
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The first experiments to produce a vacuum were proposed in 1631 by Reneri of Leiden in correspondence with Descartes [1]. The first recorded experiment to produce a vacuum appears to have taken place in about 1641 when Gasparo Berti experimented with a water barometer [2], see Fig. 1. The lead tube AB was about 11 metres long, the tube and reservoir were filled with water and the valves G, D, and B were then closed. The valve B was then opened and the water level dropped to L, a vacuum was left in the chamber above L. The experiment was not very convincing since it was assumed that sound would not travel through a vacuum yet a bell M rung in the vacuum space could be clearly heard, the sound was probably transmitted through the supports of the bell. In 1644 Vincenzio Viviani repeated Berti's experiment using a mercury-filled glass tube which was inverted with its open end in a reservoir of mercury. The experiment was probably planned by Evangelista Toricelli who was credited by earlier historians with performing the famous experiment in 1643. The

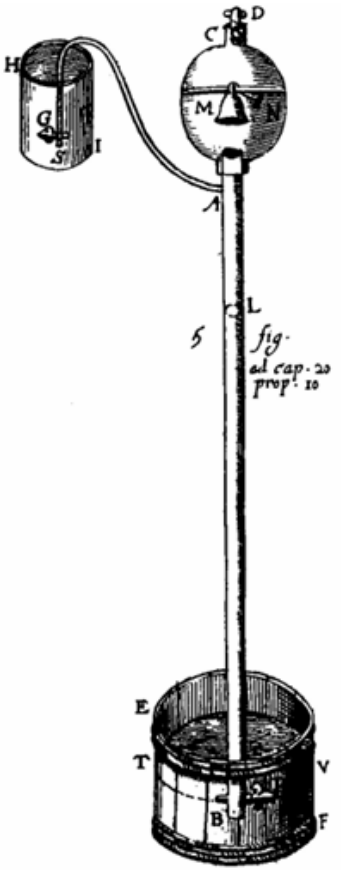


Fig. 1 The apparatus used by Gasparo Berti in about 1641 to produce a vacuum

Having discovered how to evacuate a vessel Guericke set about performing a whole series of experiments with his new found wonder. In order that we may appreciate why so many of his experiments had a permanent value, emphasis must again be placed upon the novelty of his work. It is true that a partial vacuum had been found as early as the 3rd century before the Christian era by Hero of Alexandria.[1] Hero had found that some air could be expelled from a flask by heating it. If the flask were then sealed and allowed to cool a partial vacuum was obtained. The knowledge thus derived induced Hero to try another

It remained for Otto von Guericke to solve the problem of the vacuum. How, he asked himself, can emptiness exert a force, hold down the piston of a water-pump, or draw up water? To answer these questions he embarks upon a series of experiments which consistently added to the store of knowledge.

were essentially water pumps being worked backwards. In his first experiment in the 1640s he filled a well-caulked wooden barrel with water and two strong men pumped the water out, as air rushed through the pores in the wood into the empty space a noise was heard. In the second experiment he used a large copper sphere attached to the pump; the water was omitted and the air pumped out directly. When most of the air was pumped out the sphere collapsed with a loud noise, von Guericke realised that this was caused by atmospheric pressure. A more

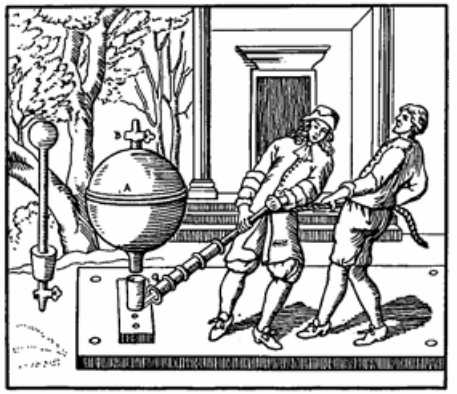


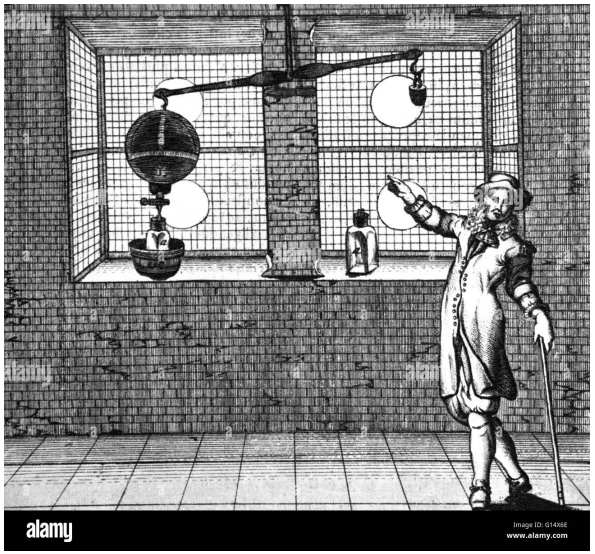
Fig. 2 The pumps of von Guericke in the 1640s. (Top) The first pump with a wooden barrel. (Bottom) The second pump with a copper sphere.

One of Guericke's most important experiments consisted of weighing a receiver, first when filled with air, and later after it had been exhausted. Demonstrating that it weighed less after exhaustion, Guericke arrived at a rough numerical calculation of its density which was much nearer the mark than was Galileo's. But, he goes further. In making observations from day to day he noticed fluctuations in the apparent weight of the receiver. He took steps to determine what caused the variation in weight, and correctly attributed it to small variations in temperature, atmospheric pressure, and its Archimedian upthrust on the suspended receiver (Book III, p. 108 et seq.). He was to make use of the knowledge derived from these experiments when he came to construct both his barometer and thermometer.

In another experiment he noted that when air from a glass vessel was allowed to expand suddenly into an exhausted receiver, a cloud of moisture formed and revealed the colors of the spectrum. Again, he remarks upon the exhaustion of gases absorbed in liquids, "the liberation of their fragrance" was immediately observed.

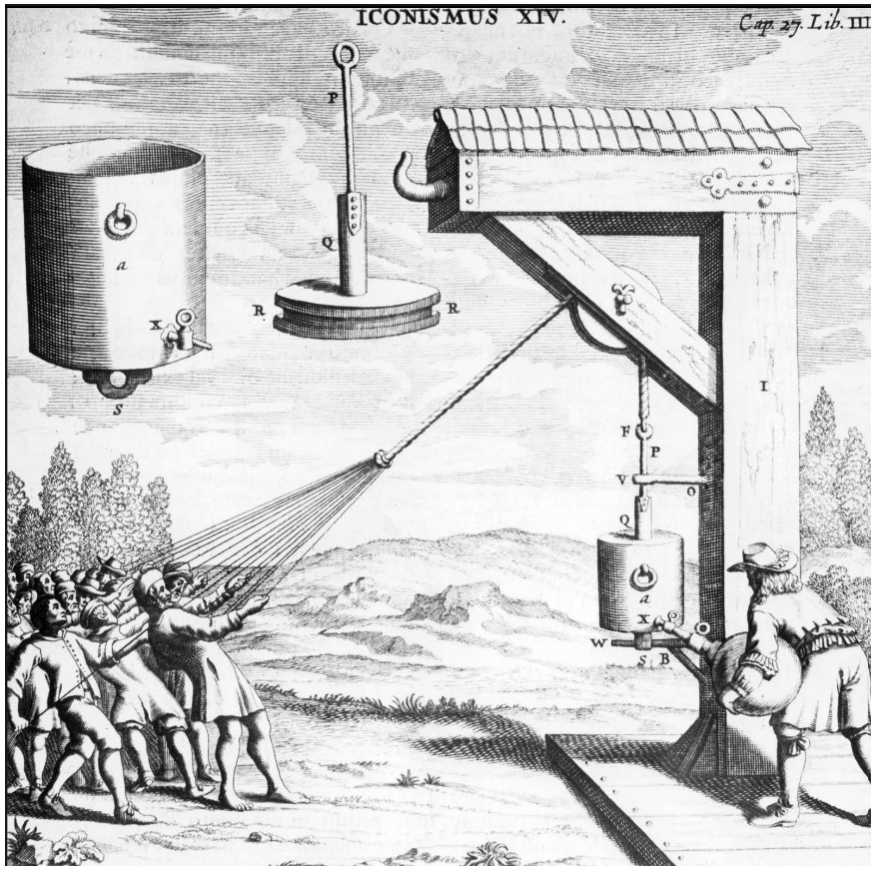
Guericke was led to experiment with living animals in a vacuum. He introduced small birds and fish into the evacuated receiver and found that they expired when the air was exhausted. He realized that air was not only a necessity of life but that breathing was a matter of atmospheric pressure, also. Grapes were found to keep in a vacuum unharmed for six months, and an egg for a whole year (Book III, p. 92).

But undoubtedly the most spectacular of all his experiments was that conducted at Regensburg in 1654 before the Emperor and the Diet. This was the culmination of his experiments with atmospheric pressure.



Experiment designed to show that air has weight. From 'Experimenta Nova ut vocantur Magdeburgica De Vacuo Spatio' ('New Magdeburg Experiments About the Vacuum', Otto von Guericke, (Amsterdam, 1672). Engraving.

A vertical cylinder, solidly fastened down, was provided with a close-fitting piston, which was pulled up by a rope passing over a pulley. This rope was divided into 20 or 30 strands, grasped by the same number of men. The men were invited to draw up the piston, no great task. But Guericke had attached his vacuum sphere to the cylinder and, on opening the stop-cock, the piston was drawn down with such unexpected violence that it pulled the crowd of men holding it, off their feet.



Otto von Guericke's demonstration of the strength of a vacuum, Regensburg, 1654. The man on the right is using an air pump to create the vacuum. Illustration from Guericke's *Experimenta Nova (ut vocantur) Magdeburgica de Vacuo Spatio* ("New Magdeburg Experiments About the Vacuum"), 1672.

before Emperor Ferdinand III at Regensburg, Guericke placed two copper bowls (Magdeburg hemispheres) together to form a hollow sphere about 35.5 cm (14 inches) in diameter. After he had removed the air from the sphere, horses were unable to pull the bowls apart, even though they were held together only by the air around them. The tremendous force that air pressure exerts was thus first demonstrated.

Fig. 3. Two teams of horses trying unsuccessfully to pull apart vacuum-filled copper spheres during the Magdeburg demonstration for Emperor Ferdinand III. From *Experimenta Nova (ut vocantur) Magdeburgica De Vacuo Spatio*, Amsterdam, Netherlands, 1672 (Ref. 4).

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apart until the air was readmitted (**Fig. 3**). Thereafter, Kaspar Schott was ordered by Ferdinand III to go on with these experiments using von Guericke's instruments. In 1657 Schott published his book *Mechanica Hydraulico-Pneumatica*, mentioning the instruments and achievements of Otto von Guericke in a supplement.

been delayed. Von Guericke, who originally did not want to publish his results, was motivated to write about his experiments due to the ever-growing public interest and scientific discussion and recognition. He finished his book *Experimenta Nova Magdeburgia De Vacuo Spatio* in 1663, but it took another decade to get it published (3). His "New Magdeburg Experiments About the Vacuum" was finally published in Amsterdam in 1672 when he was 70 years old. He sent one of his books to the Royal

The discovery of the vacuum created by Guericke's air-pump opened up a wide field of application, yet strange to say, very little work of any importance was performed upon the physical properties of gases until the beginning of the 19th century when J. A. C. Charles discovered the law which governed their expansion by heat.

Fig. 3 Piston pump designed by Robert Boyle and built by Robert Hooke in 1658-9.

Otto von Guericke

Otto von Guericke, engraving after a portrait by Anselm van Hulle (1601–1674)

Born	Otto Gericke November 30, 1602 Magdeburg, Archbishopric of Magdeburg, Holy Roman Empire
Died	May 21, 1686 (aged 83) Free and Hanseatic City of Hamburg, Holy Roman Empire
Nationality	German
Known for	Vacuum Vacuum pump Electrostatic generator Magdeburg hemispheres Anemoscope Dasymeter
	Scientific career
Fields	Physicist, politician

The original Magdeburg hemispheres and Guericke's vacuum pump in the Deutsches Museum, Munich, Germany (left), Magdeburg hemispheres, Germany (right)

Thank you