Jeff Banke/Bigstockphoto

Hooke's law of springs

The picture on pages 10-11 of this issue of CATALYST comes from a seventeenth century publication in which Robert Hooke outlined his findings on the behaviour of springs. Hooke was an employee of the Royal Society, Britain's recently-formed scientific society. His job was to present two or three different experiments each week to the assembled members of the society – and this was at a time when experimentation was new and there were no books of experiments to draw on. He had to think up the experiments and build the equipment himself.

What to look for

The picture is complicated because it contains several different diagrams. You can see the long, vertical spring on which Hooke experimented (*Fig 1*). It was fixed at point C, and weights were placed in the pan E. Below he has indicated the position of the pan as the weight was increased in uniform steps.

Also in the picture is a spiral spring (*Fig 2*). Hooke found that this showed the same pattern of extension as it was loaded.

On the right are Hooke's graphs of his results (*Fig 4 and 5*). If you have carried out a similar experiment, you will recognise the straight line graph which comes from plotting the spring's extension (increase in length) against the load (the weight in the pan).

Secrecy and publication

At the time, Hooke wasn't the only person experimenting on springs. He wanted to be the first to find the law which governed their behaviour but he didn't want to tell everyone else what he had discovered before he was ready to do so. His solution to this quandary? He published an anagram:

ceiiinosssttuv

Then, when he finally went public, he rearranged these letters to make the Latin phrase

Ut tensio, sic vis

which means: "As the extension increases, so does the force." In this way, he was able to establish the priority of his claim to the discovery. This relationship is what we know today as Hooke's law.

The illustration is complex because, at the time, illustrations were made by the process of engraving, and printing from engraved plates was expensive. As many illustrations as possible were crammed on to each plate – readers were used to this, and could easily focus on one illustration or another.

Hooke's notebook, rediscovered almost 300 years after his death. It includes a day-to-day record of his experiments and of his meetings with other scientists.

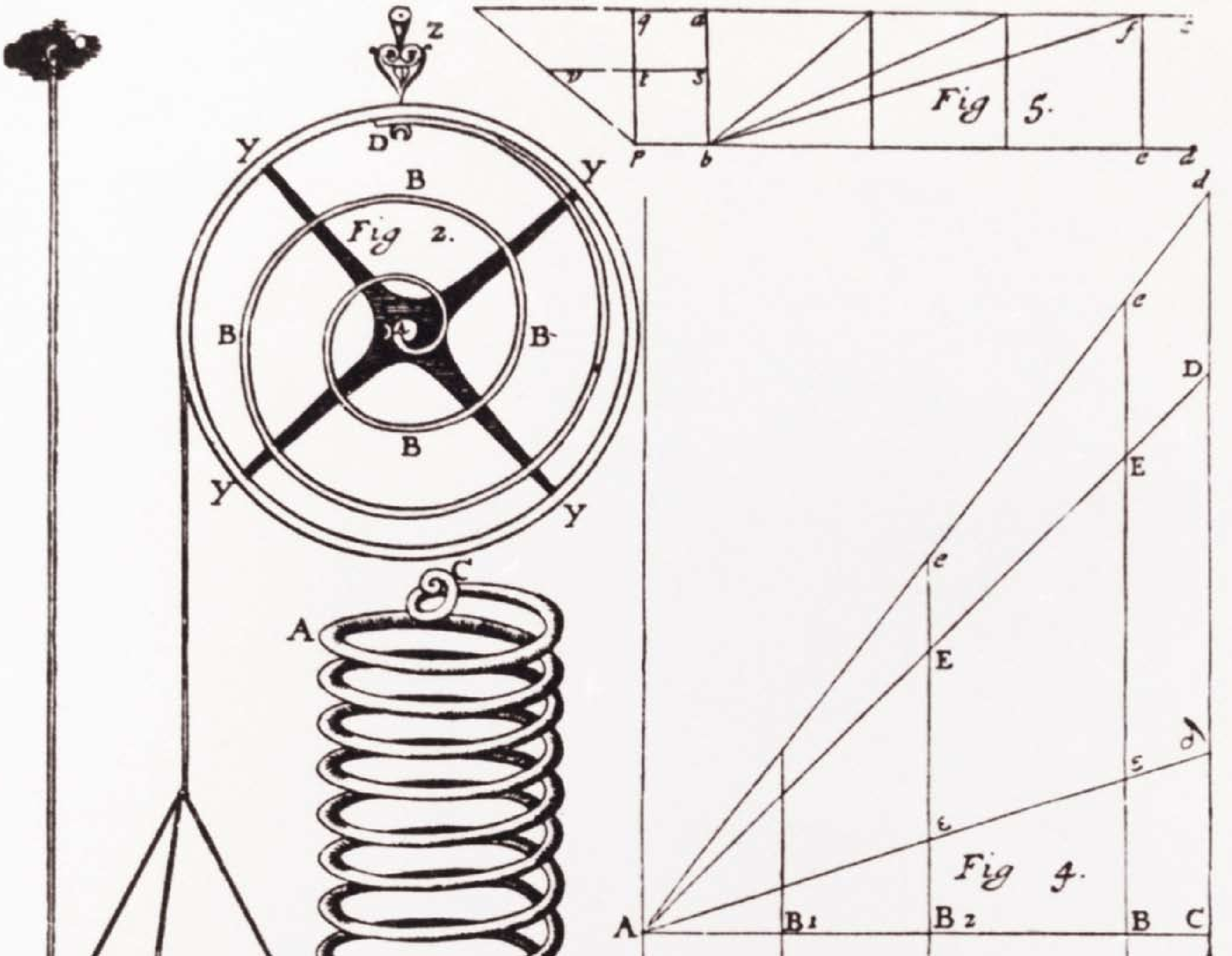
Fig 5.
q a
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Fig 2.
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Fig 4.
A B1 B2 B C
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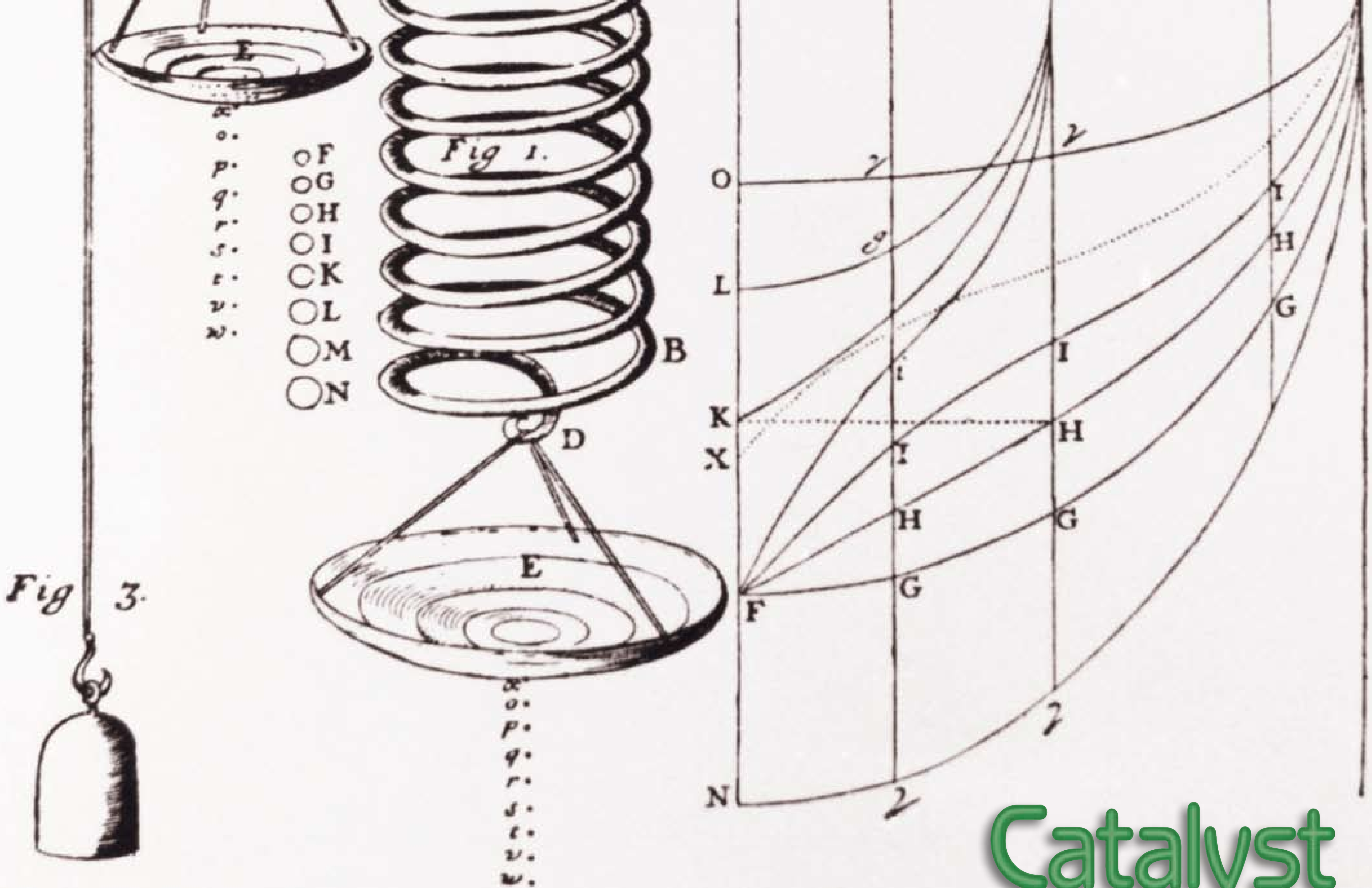

Catalyst

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Robert Hooke's illustration of 1678, showing the equipment he used to establish the law which governs the behaviour of springs, with graphs of his results.

This image of Robert Hooke, made by Rita Greer for the Open University, shows Hooke surrounded by objects linking him to his many interests – there's a spring in the foreground. There is no historical portrait of Hooke – his great rival Isaac Newton saw to it that any images of Hooke were destroyed after his death.

'A mighty ingenious fellow'

Why was Robert Hooke interested in springs? One clue can be seen in the illustration on pages 10-11. He thought it must be possible to design a clock or stopwatch which used a circular spring to control its regular time-keeping movement. (Since Galileo's time, mechanical clocks had relied on the regular swing of a pendulum.) So Hooke had to show that a circular spring would vibrate with a fixed period, whether its amplitude was large or small.

This watch (from the Science Museum, London) was made around 1675 by Thomas Tompion in collaboration with Robert Hooke, and presented to Charles II. The face has been removed to show the mechanism.

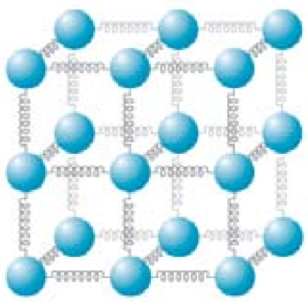
Hooke was a great inventor. He made great improvements in microscopes, telescopes, air pumps and other scientific equipment. He invented the universal joint which is in use in all vehicles today. He was also a fine architect – after the Great Fire of London in 1666, he worked alongside Christopher Wren in replanning the City of London and designing many of its important buildings.

A world of springs

But, to Hooke, springs were more than useful devices. They also related to the way he saw the world. He pictured the Earth and, indeed, the entire Universe as matter through which ran vibrations. This mechanical view of the world was different to that of his great competitor, Isaac Newton. For Newton, everything was to be explained by maths. He wrote equations for the force of gravity and for the orbits of planets, but he never gave a satisfactory physical explanation for these. When he tried to explain how light travels, he chose to describe it as particles. Hooke took the view that light, like sound, was a form of wave or vibration passing through matter.

Today, physicists agree that there was a lot of truth in Hooke's ideas. Sound waves are mechanical waves passing through matter. They can only do so because of the springiness of matter. Where does the 'spring' of stuff come from? We can picture matter as being made of atoms and molecules. Solid materials are held together by the bonds between these particles, and the bonds are springy. Stand on the floor and you squash the particles very slightly closer together. Move away and the bonds push back to their original positions.

In fact, Hooke's law of springs is really a reflection of the springy bonds between atoms. Pull on a spring and you stretch the bonds between the atoms of the spring. Let go and they spring back into place. So, in investigating springs, you are really investigating the forces between atoms.



In this model of a solid, the atoms are joined together by springy bonds, rather like the springs that make up a mattress.

Look here!

More about the life of Robert Hooke:
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