# 'WORLD MACHINES' AND WORLD-VIEWS

*Günther Holzhey*

**THROUGHOUT HISTORY**, the eternal continuity of repeating astronomical phenomena has been the subject of varying explanations. People have expressed these through the world-view current at that time, usually conveyed by their contemporary media. In the nineteenth century the rational scientific explanation of the movement of the planets began to be taken into wider circles of the general population. For this purpose educational organisations created or introduced didactic models which gave a mechanical imitation of the orbits of the planets around the Sun. This article discusses three different forms of these devices: the Orrery, the mechanical astronomical lantern slide, and the school Tellurium.

*1. Joseph Wright,* A Philosopher Giving that Lecture on the Orrery in which a Lamp is put in place of the Sun *(1766) (Derby Museum & Art Gallery, Photo John Webb)*

## THE ORRERY

'Orrery' is the name used in Britain for a large mechanical model of our planetary system, which demonstrates the movement of the Earth, the Moon and other planets around the Sun. The German name is *Weltmaschine*, literally meaning 'world-machine'. This kind of device was first built by the London clockmaker George Graham in 1707. The English name comes from the example made in 1713 for Charles Boyle, the 4th Earl of Orrery (1676–1731). The famous painting known as *The Orrery* (1) by Joseph Wright of Derby (1734–97), which was exhibited in London in 1766, shows how the exchange of scientific information and knowledge took place in the eighteenth century. The curiosity of the popular audience was great, but access to the information was expensive and only available to the well-off.

At around this time societies were established with the purpose of enhancing the education of the populace, and their members travelled from town to town with didactic models and instruments in their luggage, giving series of lectures. One such traveller was the Scottish astronomer James Ferguson (1710-76), who also made Orreries in his workshop in London. He earned part of his income by travelling between towns, probably with boxes full of instruments, in order to 'with the help of machinery, explain the laws by which the Lord has regulated and governs the movement of the planets and comets'.[1] Ferguson gave a presentation, maybe even a series of lectures, in Derby in 1762, and this may have provided some inspiration for Wright's painting.

The painting shows the improvised media which a lecturer might use to engage the audience: the only source of light in the darkened room is a small lamp in the centre of the Orrery which symbolises the Sun and allows us to distinguish the people and the device in the darkness. The astronomer, standing behind the children in an upright position, as if trying to control the interest of his listeners, is shown with features reminiscent of Isaac Newton (1642–1727). Newton, the discoverer of the law of Gravitation, created the mathematical basis for Kepler's Law of the Planets, and he concluded that the sky and the earth form one whole, with the same laws applying throughout the universe.

The mechanism of the Orrery was built in an extraordinarily careful and stable way, in order to withstand the stresses of the travel conditions of those days. The movement of the planets is not directed from the centre, but takes place by means of a large toothed gear wheel.

Few original Orreries survive today. The Bayerische Nationalmuseum (Bavarian National Museum) in Munich has an Orrery which was built in 1748, which is marked 'Made by George Adams, Mathematical Instrument Maker to His Majesty's Office of Ordnance, at Tycho Brahe's Head in Fleet Street, London'. There is also a 'Grand Orrery' in the Science Museum in London, in the King George III Collection of scientific instruments, which is similar to the one shown in Wright's painting.

The Orreries in England and the *Weltmaschinen* by Johann Georg Neßtfell, Pastor Phillipp Mathäus Hahn and other constructors of the eighteenth century were artistic, mathematically precise, unique constructions of the clockmaker's art. Using them was the prerogative of a few privileged and educated people. They served the purpose of explaining the Solar System, but just as important was their function as an impressive piece of furniture. They stood at the beginning of a development – the spread of this knowledge from the learned few to a wider group of intellectuals.

## THE MAGIC LANTERN

At around the end of the eighteenth century the magic lantern began to be put into the service of organised education, as well as entertainment. The roots of this process go back to the seventeenth century, when the Jesuits of Germany tried to accelerate their Counter Reformation. In 1671 the first known printed image of a magic lantern appeared in the second edition of the work *Ars Magna Lucis et Umbrae* by Athanasius Kircher, a Jesuit scholar who strove for universal knowledge and tried in his work to present the sum of human knowledge in some sort of order. His fellow Jesuit Caspar Schott described what the magic lantern was used for: as a propaganda device of the Counter Reformation in the fight for the souls of Protestants who had renounced their faith.

> But the presentation of these pictures and shadows in dark rooms makes a much stronger impression than those made by the Sun. Through this art Godless people could be prevented from committing many sins by seeing the image of the Devil sketched by the mirror in a dark place and being shocked.[2]

Immediately after its invention, the technology of slide projection by the magic lantern began to be used as a medium for spreading aspects of a world-view. The aim of the early Jesuit users – possibly among the inventors – of the magic lantern was to bring Lutherans, Calvinists and other heretics back into the lap of the Catholic Church. All media offer a connection which allows the transfer of information from the sender to the receiver, conveying messages, propaganda and advertisements at the same time as providing entertainment. When messages are transmitted they have

**NOTES**

1. Rose-Marie and Rainer Hagen, *Meisterwerke im Detail* (Cologne: Taschen Verlag, 2000), 329. For more on Ferguson see his autobiography, 'A short account of the Life of the Author, written by himself', which appeared in Ebenezer Henderson (ed.), *Life of J. F., in a Brief Autobiographical Account, and Further Extended Memoir* (Edinburgh: 1867), as well as in several of his scientific works.
2. Caspar Schott, Magia Optica (Bamberg: 1671), 407.

to be chosen in response to the receiver's point of view in order to have an influence and 'sell' themselves well. The magic lantern, in the hands of devout monks, had all these qualities.

In the eighteenth and nineteenth centuries various institutions used the magic lantern for their own purposes. Churches (at least those whose rites were not hostile to the use of images) illustrated sermons and hymns with projected pictures. Ingenious entertainers framed their performances with lectures, music and smoke, spreading fear and dread through their audience. Temperance societies campaigned for their goals. 'Professors' of popular science used the magic lantern as a didactic device for conveying the newest scientific knowledge. Views of faraway countries also formed part of the repertoire. There were slides relating to every topic that was current or sensational.

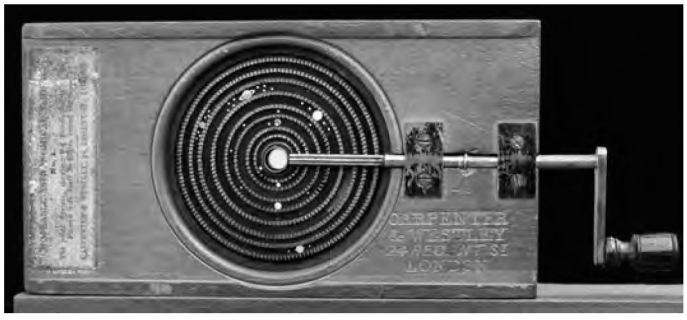
In towns, lecturers faced numerous and varied audiences. These paying spectators wanted entertainment and education, and they brought their world-view with them. In the nineteenth century, the wider circles of the European population held a world-view based on non-scientific and religious principles, based on the scripture stories of the Bible. Such world-views have a stubborn resistance: they carry the characteristics of the environment in which a person grows up.

For a lecture about the movement of the planets around the Sun, a lanternist needed a series of slides whose arguments would work on the audience like a series of successive blows. Each of them had to prove an aspect of the teachings of Copernicus, Kepler and Newton, and weaken the Ptolemaic world-view. The success of these lectures lay in their consistent simplification: each viewer had to go home with the feeling that he or she now understood the particular point being demonstrated. The style of these performances was very different from the everyday slide show. The sequences were very carefully staged, including music, sound effects, recitations and so on.

One example of the images used in this type of presentation is given by a set of ten slides produced by the company Carpenter & Westley, of 24 Regent Street, London. This business was set up in London in 1826 by the Birmingham optician Philip Carpenter, and was continued after his death in 1833 by his sister in partnership with William Westley. It became well known for especially beautiful sets of slides illustrating the fields of astronomy, history and zoology. The production of magic lantern equipment and accompanying slides continued up until the twentieth century.

The ten mechanical astronomical slides were supplied in a wooden box lined with blue material. They are mounted in mahogany frames, 94mm in height and 176mm wide (approximately 4 x 7 inches), each with a crank handle projecting from one side to operate the mechanism.

The first view (2) had to astonish the audience. Entitled 'The Solar

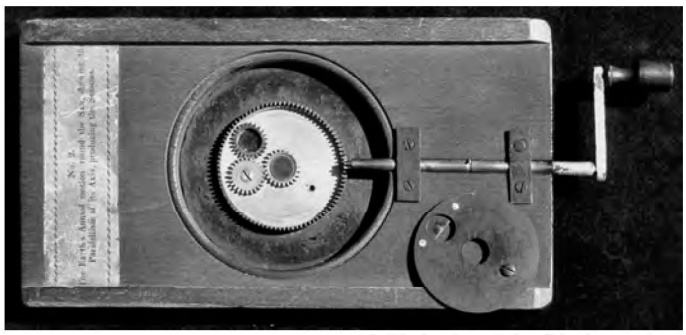



*2. Carpenter & Westley mechanical slide: 'The Solar System …'*

System, showing the Revolution of Planets with their Satellites round the Sun', it presents a small planetarium, in which the viewer sees a cross-section of the cosmos taken in the plane of rotation of the planets. Rotating the handle from the side makes the planets move in different orbits around the Sun, shown as a transparent yellow disc in the centre. The planets move on eight concentric toothed rings. The teeth of each ring simultaneously engage a drive shaft, on whose end is mounted the crank handle.

The second slide of the set (3 and 4) carries the title 'The Earth's annual motion around the Sun, showing the parallelism of its axis, thereby producing the seasons'. A planetary gearing (whose central point is the Sun) moves a tiny image of the Earth around the central

*3. Carpenter & Westley mechanical slide: 'The Earth's annual motion around the Sun*

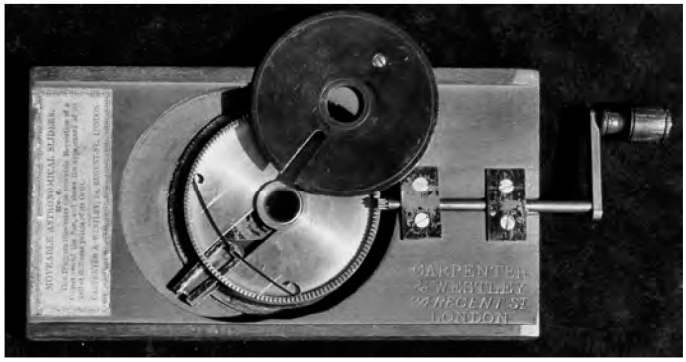


*4. Mechanism of the slide shown above*

yellow disc of the Sun. Outside this, a series of immobile miniature pictures of the signs of the zodiac explains that the apparent annual movement of the Sun through the cycle of celestial animals is a problem of our earthbound point of view.

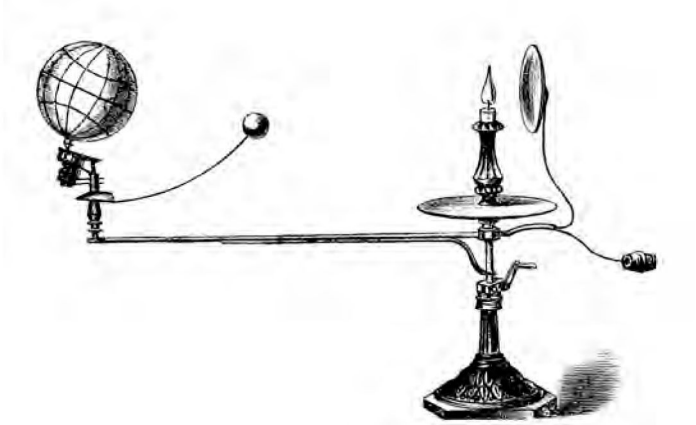
Slide 6 (5 and 6) is entitled 'The eccentric Revolution of a Comet round the Sun, [showing] the appearance of its Tail at different points of its Orbit'. In the centre of the projected picture is the yellow circle of the Sun. A comet, showing its head and tail, appears from the universe, circles the Sun and disappears again. The tail points away from the Sun. This quite complicated movement is solved mechanically by a small slider carrying the picture of the comet, which is moved along a curved path around the Sun.

*5. Carpenter & Westley mechanical slide: 'The eccentric Revolution of a Comet round the Sun …'*




*6. Mechanism of the slide shown above*

With these and other ingenious mechanical slides, a lecturer could capture the attention of an audience with a clear representation of aspects of the Copernican world-view which would otherwise be difficult to grasp. The movement of the images would convey the movement of the objects in the heavens in ways which a plain spoken explanation could not achieve.



*7. Long Tellurium, illustrated in 1911 German catalogue* Bibliotheka Pedagogica: Verzeichnis der bewährten Lehr- und Anschauungs-mittel *(Catalogue of reliable teaching and demonstrating equipment)*

*8. Tellurium made by the Felkl company, of Rostok near Prague*

**THE TELLURIUM**

In Germany, as elsewhere, much of the task of replacing the popular world-view based on stories from the Bible with that based on the natural sciences was undertaken by the school system. The overall body of knowledge covered by the concept of *Realien* (history, geography, natural sciences and nature study) did not appear in the school curriculum until the enlightenment pedagogy of the nineteenth century, which from its outset aimed to introduce natural scientific subject matter into schools. One such attempt was the curriculum for the *Bayerischen Volksschule* (Bavarian public schools) of 1804, which was influenced by the ideas of the Swiss educationalist J.H. Pestalozzi (1746–1827). Even so, this curriculum did not make its contents concerning natural sciences and other 'generally useful knowledge' compulsory, and until 1870 it was up to the teacher whether he or she included any natural scientific teaching. Progressive teachers put together their own *Naturalienkabinette* (cabinets of natural science) and taught pupils in their free time.

The introduction of natural sciences into schools was opposed by the sceptical attitude of churches and the 'new humanists', arguing that teaching based on physical sciences harms the respect for natural authorities and conveys unbelief as well as materialism. The struggle over the subjects that should be taught in schools spread to all the German states in the nineteenth century, with arguments expressed in meetings, regulations, textbooks and professional periodicals. In 1864 a ministerial order decreed that the *Realien* had to be taught in every *Volksschule*, and after the unification of Germany in 1871 the number of *Realschulen* and *Realgymnasien* (scientific or technical schools) rose and the proponents of the natural sciences finally consolidated their position.

Makers of school apparatus came to the aid of the pedagogues with mechanical models, including the Planetarium and the Tellurium (7). The Tellurium demonstrates that day and night reign at the same time on the Earth, according to which side of the Earth is facing the Sun, and also explains the formation of the seasons as well as the reasons for solar and lunar eclipses.

The construction of a Tellurium is based upon the following facts: the inclination of the axis of the Earth to its ecliptic plane is 23.5 degrees; the orbit of the Moon is inclined to the Earth's ecliptic by 5 degrees 9 minutes; the orbit of the Moon around the Earth takes 27.322 days; the orbit of the Earth and Moon around the Sun takes 365.25 days; and the rotation of the Earth about its axis takes 24 hours. Taking all these points into account, a skilled mechanic could build a mechanism to reproduce this series of interacting movements.

The devices made by the company of J. Felkl & Sohn, of Rostok, near Prague (8), can be found relatively easily today and are especially aesthetically pleasing. Jan Felkl was born on 20 May 1817 in Bohnau, near Politschka in Bohemia. He moved to Prague and started production of plaster globes. In 1858 he started to produce Telluria, in 1860 added the manufacture of Lunaria, and in 1861 that of Planetaria. Some of these had a manual drive using a handle, others a clockwork mechanism. A manual and printed maps or charts were supplied with each instrument.

In 1870 Felkl moved his successful business to Rostok. His youngest son Krystof Zikmund Felkl took over the business in 1875 and thereafter traded under the name of 'J. Felklasyn Roztoky u Prahy'. The success of the business increased as the role of the natural sciences in school curricula grew. In 1870 a new educational order stated that each Czech school should have a globe, among other teaching aids. For a long time Felkl was the only business in the Austro-Hungarian Empire producing globes; the firm became well known throughout Europe, and manufactured products in many languages. It continued in business until 1950 and was finally wound up in 1952.

The Felkl Tellurium stands on a cast-iron base on which are mounted the Sun (an oil lamp) and a horizontal disc marked with the calendar. On one side of the stand is a bracket, which can rotate around it and which carries the Earth and the Moon. The main drive axle has a handle at one end, and passes through the bracket to a gear transmission under the globe.

The globe performs three different movements:

1. The annual orbit around the Sun is created by the rotation of the bracket around the stand. By turning the handle, a gear wheel rotates on a toothed ring at the base of the stand, rotating the bracket.
2. The Earth's axis always points to the 'north pole' of the universe. On top of the gearbox at the end of the bracket stands a drive tube. Over this fixed tube is placed a movable tube, on the side of which, at an inclination of 23.5 degrees, is soldered a brass bracket carrying the axis of the globe. A gear wheel on the main shaft and a second gear in the gearbox drive the tubes, so that the axis of the globe maintains its direction during the movement around the Sun.
3. The daily rotation of the Earth. The axis of the Earth is defined by a rod which does not rotate. Over it is located a rotatable brass tube carrying the globe itself, which is driven to rotate by a gear wheel mounted on the main shaft.

The Moon is represented by a wooden ball. Its drive mechanism is fastened to the rod of the Earth's axis, where it extends beyond the top of the globe. The support structure of the Moon creates the inclination of its orbit to the Earth's ecliptic: the body of the Moon hangs on a wire, and its motion is controlled by a gear mechanism connected to the drive mechanism of the Earth.

The Felkl Tellurium demonstrates well the relationship between the three heavenly bodies, even though the astrophysical conditions are only approximately represented. It is possible to dismantle the mechanism so that schoolchildren can see how the device works. The elaborate appearance of the device might even be an obstacle to its didactic purpose; maybe the manufacturer understood that while observing the device at work, the eyes of the viewer might like to wander a little.

**THE WORLD AS A MACHINE**

From the earliest times, the unchangeable movements in the skies which people could observe without optical aids gave rise to the idea that these movements were similar to those of a very durable

machine. A vision of the world as a machine was proposed by the Roman philosopher Lucretius (Titus Lucretius Carus, *c.*99–55 *BC*) in his *De Rerum Natura*. The Egyptian astronomer Ptolemy (Claudios Ptolemaius, *c.AD* 90–168), in his *Syntaxis*, formulated the movements of the heavenly bodies as a mathematical-geometrical model, although with the Earth as the centre of the universe. In a later work entitled *Hypotheses Planetarium* he described the mechanics and physics of the heavens, and in the second part of its first book (first discovered in 1967) Ptolemy described the construction of an astrolabe, an instrument with which the movements of the heavens can be represented. The great Arab scholar Alhazen (Abu Ali al-Hasan ibn al-Haytham, *c.*965–*c.*1040), was also responsible for a detailed model of the movement of the planets.

The influence of mechanisation on world-view, in the transition from ancient to early modern natural science, lies in the introduction of the mathematical concepts of classical mechanics as ways of describing nature. The treatment of the universe as a divine machine played an important role in the development of classical natural sciences up to the time of Newton, and scientists had been searching for a secret mechanism for a very long time. They presumed that in its nature it should be similar to the tools people had been using in order to make work easier since primeval times, and believed that a skilful mechanic should be able to imitate the actual events taking place in the universe by means of a mechanical model. Physicists and scientists became used to viewing the mathematical-mechanical present - ation as a hypothetical truth. This presentation of the world reached a crisis and was finally displaced by the theory of relativity and modern nuclear physics, arising from studies in 1865 by James Clerk Maxwell (1831–79) and other physicists.

The models discussed here played an important role in the complicated task of dismantling a world-view in which the Earth stood at the central point. Nonetheless, the idea that the movements in the firmament resemble those of a well-oiled machine still influences the thinking of many people today. Such a view recalls the Orreries, Telluria, mechanical slides and similar philosophical machines in which the planets revolved at a regular pace by means of gearwheels turned by an operator.

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Translated from the German by Ester Roosmaa.

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# AN OBSCURE CAMERA OBSCURA

*Lester Smith*

*1. Stereoscopic photograph showing group by camera obscura building (Lester Smith Collection)*

**I HAVE HAD A STEREOSCOPIC PHOTOGRAPH** (1) in my collection for a long time, not knowing what it was but believing it to be very interesting. I recently showed it to a stereo-card collector friend who had acquired a collection of early stereoscopic photographic cards of Malvern (the spa town in Worcestershire, England), one of which happened to be the same image as mine. A date around the 1860s or 1870s was suggested. This would seem sensible from the crinoline dresses of the ladies and the stovepipe hats of the gentlemen. The hatless chap in the middle would appear to be the owner of the wooden construction. It looks like quite an auspicious occasion, maybe the inauguration ceremony of that building.

I had guessed by now that the building could be a camera obscura, and wrote to Malvern Public Library asking for any information. They replied with several photocopies of articles published in the *Malvern Gazette* in 1937 and 1938. The first newspaper showed a crude drawing of 'The House on the Beacon' with the caption 'Does any reader remember this?'(2). This had prompted several replies, and a picture appeared of a square stone building with a turret on top. Later I acquired, from another collector of Malvern history, a copy of the photograph reproduced in the *Gazette* (3), and this clearly shows 'The Camera Obscura, Admission 3d.'[1] There is a window in the side of the building next to it that appears to be full of photographs. The ladder and steps on the roof are curious – possibly there to allow cleaning or adjustment of the prism or mirror, perhaps to place a telescope for people to observe the landscape.


THE HOUSE ON THE BEACON.

From an old drawing dated 1877. Does any reader remember this?

*2. Illustration from* Malvern Gazette, *13 November 1937 (Malvern Public Library)*

*3. Photograph reproduced in* Malvern Gazette, *1938*

Piecing together the various pieces of information revealed that the camera obscura was built by a Mr John Down at a cost of £800, and that it was erected in the early 1870s. It consisted of a building intended as a refreshment shop which could seat 200 persons, with a receptacle for a camera obscura. It was known as 'The Beacon Building', but more personally as 'Down's Castle'. An advertisement (4) from *Malvern Commercial Prospectuses, c.*1873, refers to John Down Senior as 'an artist in photographs' who also ran the camera obscura and 'provided telescopes for viewing the scenery and the wonderful


32 MALVERN COMMERCIAL PROSPECTUSES.

THE WORCESTERSHIRE BEACON.

JOHN DOWN, SEN.,

ARTIST IN PHOTOGRAPHY,

Is now prepared to take his far-famed Photographic Groups, which stand unrivalled for Natural Backgrounds; and being the Highest Photographic Establishment in the world, with such a series of beautiful rocks, Mr. D. can photograph under the most extreme difficulties, and he invites inspection of his extraordinary Groups of Children and Picnics.

THE CAMERA OBSCURA is now open for exhibition, and being at the elevation of 1,396 feet will be interesting to visitors to the renowned Beacon. Admission 3d.

Mr. Down will provide Telescopes for viewing the Scenery, and the wonderful Spots on the Sun's disc, and will give a description of the principal objects of interest to visitors if required.

*The largest and best selection of Malvern Photographic Views kept by Mr. Down on the Worcestershire Beacon.*

*4. John Down Senior, entry in* Malvern Commercial Prospectuses, *c. 1873*