The Jacobean Space Programme - Wings, springs and gunpowder: flying to the moon from 17th century England
Transcript

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THE JACOBEAN SPACE PROGRAMME - WING, SPRINGS AND GUNPOWDER: FLYING TO THE MOON FROM 17th CENTURY ENGLAND

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Once again, it's a great honour and a great delight to speak here. The last time I spoke here, in the early part of this year, I spoke about medicine in London. Being a historian of science, I am now going to be looking at another area which I hope is topical certainly within the context of coffee house society, largely because this was born out of the very period of coffee shop society. At the time when coffee first started to be sold both in London and in Oxford in the late 1640s and created what the diarist and writer John Aubrey spoke of as "a convivial drink which men could drink [not mentioning women of course in those days] but men could drink all day and become delighted rather become inebriated and start fighting," which is one of the ways in which coffee had such a fundamental role in the spurring of the intellectual life of Britain, especially in the period of the Royal Society, which just comes slightly after the period I'm talking about today.

Now, to talk of the Jacobean Space Programme may sound rather odd. Whilst we speak of Jacobean furniture, Jacobean art, and architecture and so on, flying to the moon 400 years ago seems palpably idiotic to most people. I'd like to say why this was being spoken of at the time. It also is part of a narrow window in European knowledge at a time when there had been already colossal discoveries made in geography, in optics, in astronomy, in anatomy, right across of the range of the sciences as they were understood at that time, but also too before even more discoveries had been made which simply showed that they were totally and utterly impossible. The period of the Jacobean Space Programme, circa 1630 to 1660/65, something like that, was a sort of honeymoon period in the history of science, when immense possibilities were expected and things had not yet started to go wrong.

What were the roots of this movement? The first and the most important I think is the realisation that the ancients had got one thing after another wrong. If you look at the scientific ideas of Medieval Europe, in places like Paris and Oxford and Montpelier, Bologna and so on, you have a profound reverence for the ancient scholars, particularly for Aristotle, for Ptolemy, Hippocrates and so on, the general belief being that the Ancients knew best. They were closest to the Creation, the human mind was fresher, we hadn't degenerated, we weren't approaching Armageddon, a natural Armageddon, hence of course they knew more, saw more, and understood more.

On the other hand, things started to happen in the 15 th Century, and started a cascade which changed this. I would say the most profound things that began this movement of re-evaluating the Ancients were the great geographical discoveries, and it's not for nothing that the Reverend Dr John Wilkins, Warden of Wadham, and also Bishop of Chester, as he was in the latter part of his life, was so entranced by Magellan, by Drake, by Columbus, by all the great early navigators, the idea being that geography had not only opened up new vistas to human understanding, but had shown the Ancients to be wrong. If you look at Strabo or you look at Ptolemy or Tacitus or any of the other writers on the nature of the world in the Greek and Roman period, whilst it's perfectly true they got the shape of the world right, yes – they all knew it was a sphere, it had been measured to about 8,000 miles in diameter, all of this was known, but where they were completely wrong was on the land, sea, continent, ocean distribution. The general belief was that there was far more land on the Earth's surface than there was water, and that the big oceanic tracts of the Atlantic, the Indian, which were the only two really big oceans known in the ancient world, were little more than big lakes in a great terrestrial continental mass. The Portuguese navigator, Christopher Columbus, and then of course the great circumnavigation of Magellan show that there was more water on the Earth's surface and there were vast land masses that the Ancients had never known of, particularly the Americas, literally from pole to pole, a vast slab of land that they had great difficulty getting through into the sea beyond it. Now, what all of this does is two things. It shows that the Ancients have really come up wrong on this one, haven't they? What else might they have come up wrong on? And if we are what you might call the intellectual runts of the human litter, at the end of time and not long to go before Armageddon, why have we discovered all of these things that the wise men of antiquity never knew of? This is one important thing.

The other big thing is the method by which these new discoveries had been made. They had not been made in studies. They were not made by the ransacking of ancient texts. Nobody deduced the existence of Nova Scotia. These things were discovered by the very simple process of driving a ship into them. A ship is a form of scientific instrument. It takes you to places you couldn't swim to, and it shows you things you couldn't see if you weren't on a ship. I think it's one reason why not only the

big voyages of discovery are so important, but why also the method whereby there were made, with literally hands-on technology, became so important. Geography by 1600 had more or less mapped the world pretty well in outline, barring the Australasian land mass, to what we know today, and it had been done utterly empirically. This is a very important thing.

Another key thing are the works of Galileo. Galileo's telescopic work after 1610, his publication of Sidereus Nuncius, the Starry Messenger, in 1610, shows the universe to be a fundamentally different place to that which the Ancients had thought it to be. Galileo is pushing a very, very obviously Copernican agenda. He's saying all of my ideas clearly show the Earth moves around the Sun. Well, he's frankly being a little bit cheeky there. They didn't strictly show that, but what all of his discoveries with the telescope did do was to come up with things which are fundamentally irreconcilable with Classical cosmology. These were some of them.

First of all, the Moon had been thought by the Ancients to be a tarnished, silvery ball. Galileo's telescope showed it to be a continental place. It had mountains, land masses, what in the early days they called pits, what later we called craters, and what seemed to be possible places for habitation. Telescopes then, bear in mind, magnified 30, 40 times, and produced very, very badly abborated images, nowhere near as good as you'd get today, even with a high street telescope bought at a photographic shop, but nonetheless they took perception to a new level.

Jupiter, a bright star visible for most of the year, is shown through the telescope to be a world. It's three dimensional, it's a ball, and it's slightly squashed at the poles. It also has four little moons going around it, and these in their own right fundamentally challenged classical astronomy, because classical astronomy said all things rotate around the Earth, because the Earth is in the centre of the universe. Jupiter's four little moons, which Galileo called the Medician Stars, after the Grand Dukes of Tuscany, the House of Medici, who were his patrons, simply showed that the Earth was not the only centre of rotation in the universe.

Saturn was an absolute puzzler. Saturn had what they called ansi, which comes from the Greek word for handles of an anaphora. Why did Saturn sprout handles at the side? And why did these handles sometimes go away? Why was Saturn sometimes round, sometimes like a rugby ball, and on other occasions looked rather like a Mickey Mouse mask as they thought, where you had one ball with two big ears at the side of it? All of these appear in contemporary drawings. What they did not know at this stage is what Saturn had going around it, was what Christian Huygens discovered in 1655, as optical technology improved – notice, optical technology – a thin flat ring which nowhere touches the body of the planet, but which in the very early telescopes looked like rugby balls, blobs and things of this sort. But what was clear, Saturn was not a star. Saturn was a three-dimensional object. Venus also showed phases. There were spots on the Sun which, according to Aristotle, should have been blemishless. The sun had blobs on it and rotated in 28 days.

All of this showed that ancient astronomy was wrong. And how had all of these things been discovered? Again, just like the ship – organ pipes and cardboard tubes, with bits of glass in each end. Anybody could make one, anybody could try them out, and it's remarkable how after 1610 telescope mania hits Europe. They were often called at first "perspective cylinders", or, alluding to their original point of invention, "Dutch spyglasses". And in fact a Welsh astronomer, a close friend of Thomas Harriott, who lived at Zion House just down the road and actually did have some involvement with early Gresham, pointed out that when looking at the Moon through his telescope, he was reminded of a book of Dutch sea charts, in other words, headlands, bays, the kind of topography you find in a book of Dutch sea charts. This is suggesting that the universe is probably geocentric – is probably heliocentric, going around the Sun, but more importantly, there are things in it which are solid worlds. This becomes important. If they are solid worlds and if we had still a very imperfect concept of their distances, the suggestion there could be people living on them. This becomes a central feature in one of the components of the Jacobean Space Programme. Why should there be people living on them?

One argument, plainly and simply, is theological. If God has made habitations, then he should certainly have made habitants to live in the habitations, so therefore they should be perhaps Jupiterians, Selenites, the generic name they always applied to Moon men from the Greek goddess Selene, perhaps Saturnians, Venusians. There could indeed be an inhabited universe. Christian Huygens and his brother Constantine, a few years later in the 1670s, exchange a remarkable letter, which is now published in the Complete Works of Huygens, and this letter says, from Constantine to Christian, "How many times have you and I, dear brother, sat at the eyepiece of a great telescope and wondered if people were looking at us?" The Huygens brothers even took it further: they said what is the defining characteristic of mankind? It's intelligence, it's an ability to think abstractly, and rather apropos of Conrad Lorenz in the 1950s, we're toolmakers. Human beings make things. Why should we therefore assume that Saturnians or Moon men don't make things? And what after all is a very, very high level of thing to make, once you've gone beyond your stone axe or something like that? Philosophical instruments. Do these chaps living up there have air pumps, barometers, thermometers, telescopes, ergo, are they looking at us?

Now, this is part of the much wider idea about a populated universe and whether we might actually have contacts with it. As a preliminary to the Jacobean Space Programme, think on the one hand of trying to replicate the great oceanic voyages into the air, and then after that, the idea that the telescope has shown places and hinted at peoples that are of a kind perhaps of ourselves. Very, very centrally, none of this comes from Aristotle or from Ptolemy or from the Classical philosophers. Also, it does have, along with the rest of the scientific movement which grows at this period, a sense of finality. We think of this as part and parcel of the European Renaissance, as part of Shakespeare's plays or Talici's anthems or Michelangelo's work or things of this sort. We can think of this as the beginning of the modern world in which we live today. They didn't think like that. They thought of these things as significators of the end. It was not for nothing, on the front page of the Novum Organum, Francis Bacon's great treatise on the method by which one should do science, he shows not only a ship sailing out between two great Classical columns. Of course this is supposedly the new ship going beyond the ancient pillars of Hercules, the Straits of Gibraltar, that demarked the continental knowledge of the ancient world. Many people failed to read a little Latin text that goes underneath it.

That little Latin text is from the twelfth book of Daniel in the Old Testament, verse four, translated into English: "Many shall run to and fro and knowledge shall be increased." This was part of Daniel's prophecies for the coming of the end of the world, the visionary times of the end. "Many shall run to and fro," the great geographical discoveries, and "knowledge shall be increased," learn more and more and more. In other words, was all of the insight part of a sort of recapitulatory flash that God would give us before literally wrapping up the world like a carpet and hence the end? You have to think of their work not just as part of visionary science, it also has this wider agenda that runs with it, from history, from invention, and very strongly the notion too of sense knowledge - sense knowledge, our natural senses take us further than we can go by pure speculation.

Slightly later, 1665, Robert Hooke really hits the nail on the head. He invents the term "artificial organs". We have five natural organic senses. Scientific instruments make these more acute and more precise, and hence science advances. Hooke says in 1665, "We have discovered more in the last 150 years since Columbus than the entire Ancients discovered together, and we have discovered this by making your senses more acute so that we can now see further."

This is a rather long background to the Jacobean Space Programme, and one which I hope makes it sound not perhaps quite as crazy as it may seem at first, with the idea of men making what they called flying chariots to fly off into space. Where does the idea of the voyage to another world come from? We have to bear in mind, who were the first people to talk seriously of what you would call inter-planetary journey?

I suppose the one who wins is the Roman writer Lucan, who around 160AD wrote a work which was based upon a ship going to the Moon, literally a conventional Mediterranean galley caught up in a great storm, being lifted up into the air, and low and behold, it comes down on the Moon. The reason for this of course, it is not a book about science; it is not a book about the Moon. It's political satire, it's in the tradition of "let's go from here to a fantasy land, compare the perfection of fantasy land with what we know on Earth", and so on. Of course Lucan's voyage is not really part of serious planetary exploration. But nonetheless, they're aware of this idea. They also knew firmly by 1600 the distance of the Moon, about 240,000 miles, about a quarter of a million miles. They could establish this quite accurately by trigonometrical measurements made from the Earth, so they knew how far they had to go. Now of course that journey, compared to, let's say, the two months necessary to get to the Americas, or the three years to circumnavigate the globe, has to be put into context.

The first person to write what I would call a serious book on flying to the Moon, in other words, one which contained an undoubted fantasy component, but built around the best scientific knowledge of the day, was none other than Johannes Kepler. In 1630, shortly before he died, he wrote a book called the "Somnium", or "The Dream". It was published a few years after his death, written, bearing in mind, by the greatest astronomer and the greatest planetary dynamicist before Newton, therefore it's not going to be naïve. He talks of a young man whose mother happens to be, conveniently, a witch. He'd already studied with Tycho Brahe in Denmark, and there's a lot of autobiographical stuff in the Somnium. The mother says to him: "You're interested in the Moon. Would you like to go?" She arranges for him to go there by means of what you would call "demon power". This is the first reference to what we would now call some kind of blast-off. In fact, she says that he needs to be put to sleep because the violent shaking of his ascent would probably be alarming. He has to make the journey during a total eclipse, because in space, the Sun's life would be utterly blinding, ergo you would have to travel in the shadow of an eclipse, and of course have a number of friendly demons to bring you back again.

Then a few years later too, the great French comic writer, and he was genuinely really a man, Cyrano de Bergerac produces his "Comical History". He flies to the Moon in his "Comical History" with a novel mode of propulsion – May dew. Why on earth do you have dew falling at night in spring, and it vanishes as soon as the Sun's come up? Because the Sun clearly sucks it into the sky. He therefore says he gets up early one morning, fills a number of little glass bottles with May dew, fastens them to his coat,

faces east, and whoosh, up into the sky he goes! Not terribly scientific.

There's also William Godwin, who later became Bishop of Hereford, because in the title page of his book "A Man in the Moon", 1638, which simply has on the title page "WG, B of H", someone has written, in a 17 th Century hand, William Godwin, Bishop of Hereford, so we know who he was. This is another piece of fiction. It's about a Spanish adventurer, a sort of down-at-heel model of a celestial Don Quixote. He's called Domingo Gonzales. Domingo Gonzales, having failed to make his fortune in the Americas, is coming home to Spain, and he's shipwrecked off an island. He wonders how he can get back home, and what he does is notice that certain large birds, which he calls ganzas, come and go to and from the island. He trains these ganzas with the intention of putting them into some kind of frame, like animals before a chariot, and hence pulling him back to Spain. Works perfectly well, up he goes, marvellous ascent, but then it keeps rising and rising and rising, and we have now, for the first time I think in world literature, the ascent of an astronaut from the Earth. He mentions that the island then became surrounded by sea, then he could see the Caribbean and the Americas, and he went higher and higher, and then remarkably, he mentions that when he gets to a certain height, he can see the stars although the Sun is still shining - quite extraordinarily prescient for a story written in 1638. While this is happening is, unknown to him, the ganzas migrate to the Moon. So they take him to the Moon, he meets the king of the Moon – of course you always meet the king of the Moon, you never meet the charlady of the Moon, always the king of the Moon – and of course he comes home and tells of his adventure.

Now, these are purely works of fiction. Nobody is claiming that these are scientific books. Kepler, it's true, was writing in the best knowledge of his day. But what this does is to have a profound influence on a number of figures, one of whom is the Reverend Dr John Wilkins.

Wilkins is born in 1614, near Northampton. He comes from a family of goldsmiths and also clergy. He's sent to Oxford as a young man. He goes to Magdalene Hall. After this, he becomes ordained, and this is the period just before the outbreak of the English Civil War. He becomes Chaplain to Lord Privy Seal, who's one of the great political movers and shakers of the 1630s. Hence, right from the word go, both through Oxford and through his political connections, he's right in the heart of the London establishment. At this time, he becomes especially fascinated with cultivating an interest that goes back to childhood, and this would be what would be simply called natural philosophy, the old word for science. He'd read Galileo in the Latin, he knew Kepler's works, and he becomes fascinated by the power of the new science. One figure he had devoured as a young man and continued to revere was none other than Lord Francis Bacon, who of course I mentioned before, the author of the "Novum Organum", the greatest apostle of experimental science who had died in 1626 and whose books formed what you might call the mother's milk to the English experimental community.

Throw in Bacon's experimentation with all of these other factors, the fictional literature, the voyages of discovery, the telescopic discoveries, and this is the genesis of the Jacobean Space Programme. Now, Wilkins produces a book, in 1638 when he's only 24, and this book is called "A Discovery of a New Planet". It's the first book really to popularise Galileo's ideas in English. It's true that some of Galileo's works were already available in English translation, but these were learned works, and what Wilkins produces in his Discovery is a book, intended for the lay reader, the kind of person who is not a scientist but has an active interest in these things and probably does not read Latin – very, very importantly. He takes you through all of the basic arguments, about the size of the universe, the fact that Jupiter is a world, that the Moon is a world, and all the rest of it. Then, in what he calls Proposition 14, or Chapter 14, the large chunk at the end of the book, he talks about "whether it be possible to fly unto that world by means of flying chariots", some kind of mechanical conveyance. He also speculates as to the existence of the Selenites and with that kind of combination of ingenuity, promotion of learning and good business, which has always been a hallmark of the City of London, he adds the rider "and can we have commerce with them?" In other words, can we trade with the Selenites in the way that we trade with people in India, or the Americas? Can we trade, literally, with the Moon, have commerce? The word "commerce" in the 17 th Century had a wider meaning than today. It didn't just mean business trading, it also meant connection, understanding, but very, very clearly, there's the idea of having commercial relations with the Selenites. He has to admit he can't be sure that the Selenites exist: They should do, but nobody's seen them, but after all, it's probably a fairly good bet that they're there.

Now, how do you start flying? Well, Wilkins first of all draws heavily on the writings of Dr William Gilbert for this early idea of going to the Moon. William Gilbert had been physician to Queen Elizabeth I, and as Queen Elizabeth I was an extraordinarily healthy woman who did not trust doctors, her medical advisor didn't have a lot to do. So Dr Gilbert had a lot of spare time on his hands, and from about 1570 onwards, he started to perform experiments on magnets. These would be bar magnets, iron magnets. He discovered a lot of the things which would nowadays be sort of pre-GCSE Physics: you take a bar magnet, you put a piece of paper on it, sprinkle on iron filings, flick the paper, and low and behold, all the lines will appear. He said you can do the same with

a spherical magnet, which he called a terrella, a little Earth, and he assumed the Earth to be a magnet, with a north and a south pole, and what he called “lines of force radiating between these places”.

One of the crucial problems at this early period is that the connection between magnetism and gravity was frankly confused. Both were known to be invisible things which acted as what they called “at a distance”. In other words, A would affect B without any visual connection going between them, therefore gravity and magnetism seemed to be connected. Wilkins also takes up one of the ideas of Gilbert, that any terrella, or any magnet, has a limited field around it, so that if, let’s say, you hold a compass two feet from a magnetised cannonball, it often won’t even affect the needle. Bring it closer and closer and then suddenly the needle will flick over.

What Wilkins suggests is that the Earth probably has a magnetic or a pole field that is limited into space. He therefore conducts a number of experiments, and seems to collect material from others, from things like triangulating the heights of clouds, which he works on the assumption that they are the flimsiest things known in nature and hence can probably fly the highest, and comes to the conclusion that the Earth’s magnetic field must stop definitely at 20 miles. Ergo, if we can rise 20 miles, we should be able to push off into space. This is one of the central tenets of his thinking, born of good solid observational work. The fact that, in 1638, he didn’t know that magnetism and gravity weren’t the same, frankly, you can’t blame him for.

He then talks about how you get off the ground and how you get up 20 miles. He has a number of suggestions, and part of the honeymoon sense of the exhilaration of this period is that Wilkins is of the opinion that we’re almost flying already. You look at literature, certainly look at modern literature, and people are just literally leaping into the air and going two furlongs and things of this sort. He mentions, for instance, even a century earlier, the great Viennese astronomer Regio Montanus who allegedly had made an iron fly, powered by clockwork, that flew out of the city of Nuremburg, greeted the Holy Roman Emperor, and flew back again, rather like a sort of model aircraft. What this thing was we don’t know, but certainly iron flies weren’t flying around in 1500. Nonetheless, it’s part of what he adds to the general argument.

He says too that people think that flying is absurd, but frankly, there are lots and lots of things that we take for normal in life which would seem absurd. Horse riding, for instance. He says: “Horses are great big strong strapping beasts. Who would ever from a cold start assume that you could tame them so you could sit on their back and run at great speeds on them? ”Tightrope walkers and circus performers are another: “It would seem absurd that a man could walk or dance upon a wire, but they clearly can. Why can’t we fly?” Now this is part of his ingenious optimism. All of these things seem impossible from a cold start, but they’re here – why not flying?

He then starts to throw in examples of proven flying. For instance, we’re told, from legendary tradition from the Acts of the Apostles, that in Rome, Simon Megus had challenged St Paul to a flying competition, to fly from the Avantine Hill to the Capitoline Hill, and that when Simon Megus almost won, a bolt from heaven knocked him out of the sky. The key thing is of course he was flying. And then there was a monk living at the Abbey at Canterbury just before the Norman Invasion, about 1062, and this is well recorded, this is in the Anglo Saxon Chronicle, who flew from the top of what was then the old pre-14 th Century cathedral at Canterbury, and flew two furlongs in a winged device. It’s true he broke his legs, but two furlongs wasn’t bad going! Wilkins mentions too that he knew men who were making machines and studying flapping wings and so on, and the image that comes over is you only need to get maybe 10 or 20 gentlemen, who will throw in 20 guineas apiece, appoint a good blacksmith, a good ingenious mechanic, give him some drawings, and before long we’ll have a workable machine going. The key thing was how do you power it?

Wilkins has his own fascination with mechanism. Springs were the new wonder technology of the 17 th Century. Not only clocks, which were already familiar since the Middle Ages, but much more importantly, automata – little model vehicles that moved on by themselves, like clockwork cars on the floor, things driven even by the wind, little men that walked. There was a tremendous rage for clockwork automata in the late 16 th, early 17 th Century, and it seemed that once you had enough power torque in a spring, then you could release it through that other wonderful thing, a gear train. What they did not know is that gear trains suffered from inertial resistance, and Wilkins worked on the rather blasé assumption that you can perhaps have several million to one upstaging from a simple spring which can then, let’s say, flap the wings of a flying machine.

All of these things go together to produce his marvellous image of some kind of ship-like vehicle, his flying chariot, based upon the load carriers of the oceans, but containing a powerful spring, a clockwork gear train, and a set of wings. He points out that you have to have wings that are covered with feathers from the right kinds of birds! Hens are no use. Hens don’t fly. You want the feathers of high flyers, swans, geese, birds of that kind. “Those kinds of feathers have a natural affinity,” he argues “for the high air,” and you also probably make a machine that takes off on what we would think of today as a fairly low take-off plane,

rather like a 747 or something of this sort. He points out that when you look at large birds taking to the air, swans and things of this sort from the water, they always do it from a low angle. It's very, very much work for them, but the higher and higher they get, the easier and easier it becomes, until finally they're hardly moving their wings at all. This is because, he says, they're now releasing themselves from the natural pull of the Earth.

This basically is his model of his flying machine. You may say though, as he was fully well aware too, if you're going to have a journey to the Moon that will last months, what are you going to eat on the way? What are you going to breath? Well, food he dismisses fairly conveniently. He says eating is a degenerate habit, we don't really need it, and he cites, as he always does with that extraordinary compendium of scholarship that he has at his fingertips, people who lived long periods without eating. He mentions for instance, good Protestant as he was, of a man whom the Popes had in the custody in Castel St Angelo in Rome who lived for 40 years on mere air! And there was also the case of a German peasant, who allegedly at a village feast, at harvest, fell asleep with his pint mug under a hayrick, was completely forgotten about, and 6 months later when they were removing the hayrick, they found him still lying there, snoring away happily with his pint pot, and none the worse for not having eaten for six months. So Wilkins can always draw these cases out of the air, but of course he has a real reason why we can survive in space. Quite simply, in space, there will be no pull on our digestive organs. We get hungry because gravity or magnetism or whatever you want to call it is constantly irritating our insides and making it necessary to fill them up with food. Once that has stopped, you won't feel hungry.

What about the obvious choking effects that one can experience at great altitudes? Mountaineers and people of course were climbing mountains in those days. Does this mean that the air gets unbreathable in space? He suggests that this is not a problem at all. This is simply because human lungs are not accustomed to the pure air breathed by angels, and once we have become accustomed to this pure air of the angels, we'll be able to breathe it. Effectively, therefore, he argues that what all of this will lead to is that with a bit of discipline, a good bit of investment and some ingenuity, we will be able to get up there 20 miles and on to the Moon.

He develops the ideas of the flying chariot in three books – the first and second edition of his journey to the moon, or his Journey to a New Planet, as he calls it, 1638 and 1640, and then, 10 years later, the year in which he becomes Warden of Wadham College, he then publishes Mathematical Magic, an immensely influential book, a book which influenced many others, including Robert Hooke, and many people who were to be of the next generation of scientists, the men of the early Royal Society. Mathematical Magic is subtitled, *The Wonders of Applied Mechanical Geometry*, and this is about flying chariots, wind cars, guns that will have multiple shots, ingenious devices all over the place. It shows the immense sense of optimism of what they thought technology could do, including a wonderful section on how you could use the wind from a mere puff of a man's breath to uproot an oak tree with an enormous gear train, the idea being that you don't need much of a spring to have enough gears to make the thing fly. Wilkins therefore had tremendous influence in his time.

One of the key things which does not happen is that he never becomes a man on the Moon. We do know that he experimented with these things in Oxford and almost certainly in London, where before becoming Warden, he was part of the original Gresham group out of which the Royal Society came, so he would have known Gresham College in Bishopsgate Street like the back of this hand. He was friend of people like Lawrence Rook, the professor of geometry, and then, a generation later, when his own pupil, Robert Hooke, became professor at Gresham, he would have known him there as well. So he's moving in these very, very well connected and ingenious circles, but he never gets to the Moon. But what he is doing in the 1640s and 50s is very influential.

We have to bear in mind that the backdrop to this whole movement is the English Civil War and the Cromwellian period. Wilkins was one of those consummate diplomats, a man who really found a way of getting on with most people, in what were called by John Aubrey "these troublesome times". He marries Oliver Cromwell's sister. He then starts to develop very close connections with Cromwell himself, and at the time of the Cromwellian Interregnum, and when Cromwell dies in 1658, John Wilkins is a member of the Council of State, trying to advise Richard Cromwell about the governance of England. He's already of course Warden of Wadham in Oxford, and in the last eight months of the protectorate, he becomes Master of Trinity Cambridge. So there he is an immensely influential figure.

Don't at all think of Wilkins as some crackpot who had rather wonderful ideas about flying to the Moon. Here is a man at the centre of the establishment of mid-17 th Century England, ecclesiastical, intellectual, scientific, but in spite of all of these connections with the Cromwellian government, he was certainly no Puritan, and frankly disliked Puritanism. As Warden of Wadham he made the College what was called by Anthony Wood "a haven", a haven for young men who would normally be banned by the Protestants, or more correctly, the Puritan universities. It included people, for instance, like the young

Christopher Wren, later Sir Christopher Wren, son after all of the Dean of Windsor and nephew of the Bishop of Ely. His father had been Chaplain to King Charles I. You can't get much more Royalist than that, but Christopher Wren becomes one of Wilkins' boys. Wilkins also takes up Robert Hooke in the same way. Seth Ward, Thomas Willis, and a whole variety of figures, start to form his private club of friends, what they came to call the Oxford Philosophical Club, the word "philosophical" in those days being used for what we would now call scientific, to pursue experimental knowledge.

Now, all of this is happening, flying to the Moon, experimental science, cultivating a wide variety of people across the spectrum, and also helping to govern England, especially towards the end of Oliver's reign. And then in 1660 the Restoration comes and King Charles II is on the throne. This group of men, two groups who had met both at Gresham and at Oxford, now apply to the King for an official position of state. The King of course is broke but very well intended. He gives them the Royal Society Charter, the name the Royal Society, the Society's ceremonial mace, and various other ceremonial articles, which of course are precious to the Society today, but no money. The key thing is that all of these men now move to London. They leave Oxford and they start to re-meet in Gresham College London.

On the other hand, what happens to somebody who's married to Oliver Cromwell's sister? Well, with that extraordinary ingenuity of Wilkins, he gets appointed to a couple of very, very good City livings. He is of course an Anglican at heart. He'd never liked the Puritan movement, although he worked very easily with the more moderate Puritans. He then becomes Dean of Ripon, very quickly, and in 1668, Bishop of Chester. Any man who can be Oliver Cromwell's brother-in-law and die an Anglican Bishop was a diplomat, whether he thought of going to the Moon or not!

What about the abandonment of the Jacobean Space Programme? Well, the group of friends whom Wilkins assembled around him, mainly in Oxford and at the meetings at Gresham, start very quickly zooming ahead on his original ideas. Boyle and Hooke, with the early work on the vacuum, come to discover by 1660 that space is probably a vacuum. Piccard in France takes an early barometer up the Pyrenees, and finds that not only does he become progressively out of breath, but two other things happen. The mercury in his barometer sinks and sinks and sinks and sinks, and it becomes easier and easier to boil a kettle, suggesting therefore that there's less pressure up there. Generally, by 1665, space was now known to be a vacuum, and you couldn't fly through it. Likewise Wilkins came to realise, with the growth of knowledge of clockwork and mechanics by the 1660s, that you would never have a spring strong enough to make a machine lift off the ground to go any distance.

On the other hand, you may say, where does the gunpowder come in? (I mentioned gunpowder in the title of this lecture.) They never thought of using gunpowder as a form of propulsion, but they were suggesting it as a sort of primitive internal combustion engine. If you had a very powerful canon with some kind of plunger, rather like a piston, perhaps you could use the explosion of a canon to tension an immensely strong spring, hence you could use an explosion to generate the mechanical energy for the springs.

Finally, although Wilkins realised, certainly by the time he became Bishop of Chester in 1668, that you would never fly to the Moon the whole perspective of scientific knowledge had changed beyond recognition in the intervening 30 years. He nonetheless was aware that perhaps these machines would be useful for terrestrial travel. For instance, why not have a machine that could fly up for 20 miles, get outside the Earth's pull, switch the wings off, and wait for the Earth to turn around you? And so if you were flying to, let's say, Boston from England, you just simply fly down to the latitude of Boston, somewhere over France, hang there in space, wait until Boston had become below you, and go straight down. He suggests this as a mode of travel around the world. After all, China in ten hours, you simply can't beat that! The fertility of this man's imagination is incredible.

If you look at the portrait of Dr John Wilkins which hangs in the Senior Common Room in Wadham College, Oxford, I think the geniality of his face comes over, and one can understand how he was a figure who won friends very, very easily.

Wadham College, Oxford at the time looked very much like 17 th century Gresham College. It had a walled Medieval gatehouse, the great enclosed place, where you have the front gate– of course in Gresham's case it was Bishopsgate Street – and all of the staircases, chapel, dining places within the great quadrangle. It was probably in ornamental gardens. You couldn't try out spaceships there, but we do know that there was a sort of home farm, and it was probably in the fields of the home farm. We know this happened because in 1674 Robert Hooke has an entry in his diary, that he was attending a meeting at the Royal Society where one Dr Croon, a famous anatomist, was giving a lecture on birds and how they fly, and he says: "I did say to Dr Croon that Dr Wilkins and I did make flying machines in the gardens of Wadham College, Oxford, 20 years ago, circa 1654."

A mid-16 th century engraving shows the use of water power, and part of this sense of the wonder of mechanical force. It

depicts a stream, and a number of little sluices, each one powering wheels, the idea being, that a wheel, through a crank, makes the hammer go up and down and hence you can use it for forging metal. It was part of a much wider culture of the sheer fascination with mechanical technology.

Another wood-cut, 1620, shows an Oxfordshire-peculiar stunt called the Flying Ship of Lamborne, where something of an entrepreneur had the idea of a pair of ropes up Lamborne Church tower, where a small model ship, big enough for him to sit in, was being pulled up and down, and the very idea of the image of a ship literally going into the air, I think, has an enormous power in the Flying Ship of Lamborne.

Another picture shows one of Wilkins' devices about the powers of spring.

There is a man blowing into something rather like a child's windmill. All of the gears rotate, and out of the ground, comes the oak tree – a puff of breath pulls an oak tree out of the ground. Of course it doesn't really follow the laws of dynamics as we understand them nowadays! Put a clockwork motor up there, put a pair of wings down here, and you're up 20 miles.

Wilkins was always bringing in ingenious inventions he knew of in reality. There was a wind ship a rather dangerous looking contraption which shot across Holland at something touching 30 miles an hour. Now being in this device at 30 miles an hour with a good headwind from the North Sea behind you must have been hair-raising to say the least! But his idea is something that can perhaps do that and then go up into the air as well.

Another of Wilkins' suggestions is a wind car – with a rotary vane and a differential axle on the back wheel, and you now have a wind car which can drive in any direction because the vane will rotate irrespective of the wind's direction.

I hope I've given you some idea of one of the extraordinarily fruitful periods in not only British but European scientific history. One of the great things about this movement is the flash quality about it. By that, I don't mean flash as cheap, but rather suddenness, the fact that all things which seemed to be coming together by about 1630, but which by 1660 were obviously recognised to be technologically impossible. But I do think that the Jacobean Space Programme warrants at least some recognition in a wider understanding of the history of science, and all of these men were connected in one way or another with Gresham College in Bishopsgate Street.