Rebuilding history:

The first night of television

You may have watched *Television's Opening Night: How the Box Was Born* on BBC4 last November, a 'behind-the-scenes' recreation marking the 80th anniversary of the first British live television broadcast in 1936. Zerb editor **Hazel Palmer** went to Cambridge to talk to the engineers behind this fascinating glimpse into the birth of our industry.

Back in the 1930s the BBC had been chosen by the government to formally launch a regular television broadcast service. In their search for effective broadcast technology, two competing systems were trialled – one created by TV pioneer John Logie Baird, the other by Marconi-EMI. Logie Baird's two-part system involved a mechanical 'spinning disc' camera transmitting 240-line moving pictures over the existing medium-wave wireless radio, whereas Marconi's 405-line system used electronic scanning and a cathode ray receiver.

It had already become very clear to the BBC that the EMI system was far superior to Baird's, but Baird had gained popularity in high places, so under government pressure the BBC would trial both systems. As such, British television's official opening night was broadcast live from two separate studios at Alexandra Palace, using first Logie Baird's system, then Marconi's.

We are mostly familiar with the Marconi system, which remained in use until the 1980s, whereas there is little left of the rather cumbersome and problematic Logie Baird system. Much of his work was destroyed in a fire, so all that remains of his 'flying spot' camera are a few photos.

Recreating Logie Baird's system

In order to recreate Baird's original system, the makers of the BBC4 programme approached Dr Hugh Hunt, Reader in Engineering Dynamics and Vibration at the University of Cambridge, to see if he could build a mechanical camera using Baird's techniques. Dr Hunt had worked on a few projects for Windfall Films before – his knowledge, coupled with an infectious enthusiasm for practical experimentation, had made the perfect combination when it came to recreating engineering marvels for such programmes as *Dambusters: Building the Bouncing Bomb* and *Escape from Colditz*.

I personally heard about the Logie Baird project from my nephew, Arthur Tombs, a PhD student working with Dr Hunt. He had asked me if I knew where they could find an original 30-line television similar to that used to broadcast the Baird pictures. He had gone on to tell me about some of the problems they were having in their attempt to build a disc big enough and that could spin fast enough to create a detailed moving image. I had known nothing about Baird's mechanical system, so after watching the BBC programme and getting an idea of how it worked, I was curious to see for myself the recreated camera at the University of Cambridge Engineering Department and to talk to Dr Hunt about how he had approached the task. I began by asking how he worked out how to build the system with no plans or existing models…

Dr Hugh Hunt with the discs made by the University of Cambridge Engineering Department

Dr Hunt: In the 1920s and 30s there were lots of amateur enthusiasts and Logie Baird was one of these. There were plenty of articles in amateur magazines and journals – although mostly in Dutch and German. There was a real hobby thing going on. The basic principles of Nipkow disks* were pretty well understood but only at quite low speeds and low resolution – if you wanted to do 15 frames per second (fps) and 60 lines, it was really easy.

This disc with the red spots (*see image above*) is the first one we used. It's about 25cm in diameter and has 30 holes in a spiral. This can be spun up with a handheld drill quite easily and it's pretty easy to shine a small light onto a square area and project the spot onto someone's face in a dark room. You can be up and running with this system in a day.

Next we tried spinning a 60cm diameter disc with 60 holes (blue spots) at 15fps, but we needed a four times bigger disc to spin it at 25fps and this becomes physically impossible. It's just too big. Logie Baird couldn't do it either, so what he came up with was a multiple spiral scheme. He ended up with four different size spirals in a complex arrangement and the disc had to spin four times faster. It was really complicated, but Logie Baird did it.

Next he had to make it spin at 6000rpm to get his 25fps, but if you are spinning this thing at such a ridiculously high speed, what happens if it blows apart? Someone's going to get hurt. So it was enclosed in a safety cage and, because of air resistance, it became clear that if you could suck the air out to make a vacuum it doesn't require so much energy to spin. Getting all this to work was, well… you have to be a bit of a nutcase to try it, and I think he was a bit of a nutcase!

So how was the signal sent to people's homes?
Dr Hunt: The clever thing is that it was done by wireless with exactly the same transmitter used for radio transmission. The spot of light scans the subject and the reflected light is picked up by photo sensors. These create a voltage proportional to the amount of light that's hitting them and that information is sent down a wire. As far as the radio is concerned, that signal looks like a sound signal so it can be broadcast. The decoding at the other end is the clever bit. At the end of each scan line there would be a little blank spot, so the signal would go blank and the tube would start a new line. Once you got to the bottom you would have about 20 lines of complete blank so that's when the TV receiver knew to spring the electron beam back to the top and start a new page.

It would have been great to do exactly what Logie Baird did, but I could see it wasn't going to be easy and we weren't going to be able to build anything at 240 lines and 25fps given the budget. Logie Baird took decades to get it to work, so we couldn't be expected to do it in a few weeks!

Would you like to if you had the time and budget?
Dr Hunt: No, not really, because it would be difficult, hard work and very time-consuming. I'm really thrilled to have done this because it has opened up a window I didn't know anything about. I think people watching the film learn a lot.

The film didn't really mention the Marconi-EMI system?
Dr Hunt: I think people know how television works now (which is much more similar to the Marconi-EMI system), so it's easy to think 'Well, TV then was like TV now but just more primitive', whereas the Baird system is completely different. It's a bit like the difference between, say, the Wright Brothers' aircraft and a modern plane. The Logie Baird spinning disc camera is such a foreign concept – that's what made it interesting for me.

Back in the 1930s, Baird used huge photomultipliers to pick up the reflected light from the presenter's face, so two super-sensitive photomultiplier tubes were borrowed for the TV show. Now, back in the lab for demonstration purposes, Dr Hunt has installed more economical microelectronic light sensors in a frame placed in front of the presenter.

The powerful theatre light focused through a lens has also been replaced with smaller, cheaper LEDs to achieve the very bright light needed to shine through the small holes of the disc. So... not theatre lighting or big old-fashioned valve photo diodes, but nevertheless everything up untill now is pretty faithful. However, this is where the authenticity had to be somewhat abandoned… and my nephew came in with his computer programming skills.

**A Nipkow (sometimes Anglicized as Nipkov) disk, also known as a scanning disk, is a mechanical, rotating, geometrically operating image scanning device, patented in 1885 by Paul Gottlieb Nipkow. This scanning disk was a fundamental component in mechanical television through the 1920s and 1930s.*
Wikipedia: Nipkow disk (https://en.wikipedia.org/wiki/Nipkow_disk)

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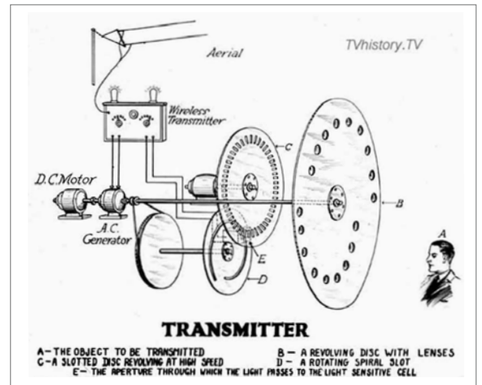
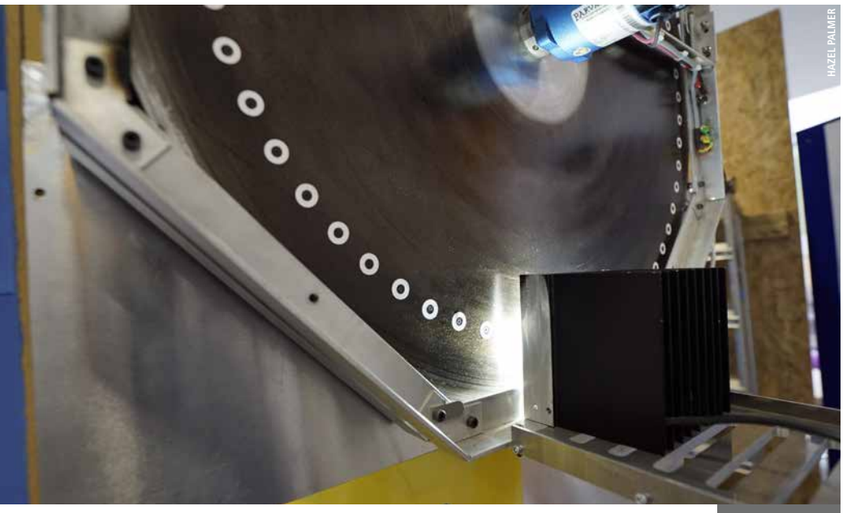
Arthur: The live broadcast was the next stage. You take it from the wire through a transmitter, which turns it into electromagnetic waves, which then get picked up by the antennae.



Baird television transmitter diagram

Interior of the darkened room showing presenter's seat and light sensor frame



The spinning disk with LED light shining through the holes

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What type of TV would you have needed?
Arthur: We were aiming for 120 lines but only got 60 lines on the finished product. With so little in the way of timing signals, I don't think any of the real TVs would have accepted it. The system we had created generated the picture but without any of the control signals for the vertical and horizontal sync. All of that is additional information which cameras need to provide, but because we weren't actually producing that information we were always going to need to cheat.

So how did you transmit your picture?
Arthur: The voltage you get from the light sensors is proportional to the amount of light that's hitting them, so all I needed to know was how fast the disc was spinning and therefore where I expected the beam of light to be pointing within the box and where the light should be. That's where we're cheating a bit; we have a second sensor on the outside of the disc, which generates a pulse every time the disc goes past, so instead of there being dropouts in the video signal we're just sending it over a second wire.

I combine those bits of information (from the slotted switch on the outside I know where the beam should be pointing and from the photomultipliers I know how much light is arriving at that point) so I just need to plot it like a graph. I have a grid of points where the x co-ordinate shows how much time has elapsed in one line and the y co-ordinate shows which line of the image I'm talking about. I set the brightness of each of those pixels according to the voltage from the photomultiplier tubes... and I make the pixel more white if the number [voltage] is higher.

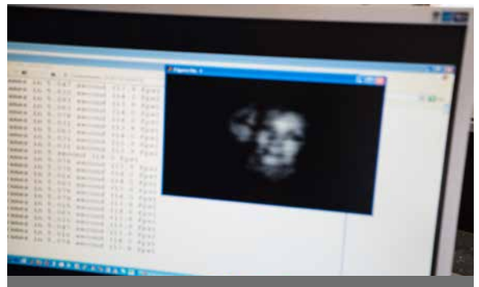
You have to get that timing exactly right. This was the most difficult thing actually. If you don't get the timing right then you just get weird smears of pixels and it doesn't look like an image.

How was the filming? I think there were some problems on the 'opening night' with the disk squeaking loudly?
Arthur: Yes, that caused a bit of friction (literally!) between us. We'd had a problem with the disk scraping at the top […] so we kept fiddling around and adding gaffer tape, but in fact we were looking in the wrong place. It turned out to be such a simple thing – the hub in the middle needed oiling.

It was a shame they cut out the whole Lego aspect of the project. Originally we recruited nearly 30 students to work on this and half of them were building a working Lego version. The Lego model was tiny, it had a laser pointer and was obviously very slow – about 1 frame every 3 minutes rather than 25fps. They worked on it for a few months I think, and they were filmed quite a lot, but then the producers made a call not to include it.

Baird demonstrating his invention with the aid of ventriloquist dummies

One of the good things to come out of it has been open day demonstrations and school visits. We've taken the Nipkow* disks with torches around to primary schools to get them interested in engineering.



The live image transmitted from the mechanical camera to the computer screen

The camera system is currently still assembled in Cambridge but taking up space in the engineering faculty. I ask Dr Hunt what will happen to it.

Dr Hunt: It's a nice demonstrator; people like to come and see it, but ultimately this isn't going to stay here for ever and if anyone wants to take it on they can, but it'll probably end up as scrap sometime soon, because that's what happens.

Dr Hunt does, however, have a student working on it this year to develop a small portable kit that can be taken round schools to demonstrate and perhaps inspire a John (or Jane) Logie Baird of the future.

Dr Hugh Hunt

Charlie Houseago (Trinity), Anna Maria Kypraiou (Newnham) and Arthur Tombs (Queens)

Fact File

Dr Hugh Hunt is Reader in Engineering Dynamics & Vibration, Academic Division: Mechanics, Materials & Design; Research Group: Applied Mechanics.

Arthur Tombs is a graduate student of Queens' College, Cambridge, studying for a PhD in Engineering.

Other students who featured in the show: Charlie Houseago (Trinity), Anna Maria Kypraiou (Newnham).

Television's Opening Night: How The Box Was Born by Windfall Films, was broadcast on BBC4, Wednesday 2 November, 2016.

More info: www.bbc.co.uk/historyofthebbc/research/general/tvstory1

Bill Vinten GTC University Awards Presentation 2017

Portsmouth University
Thursday 19 October

The fifth Bill Vinten GTC University Awards will be kindly hosted by last year's winner, Portsmouth University, on the evening of Thursday 19 October.

As the competition becomes more widely known, it has this year attracted new entries from Wiltshire College, The University of the West of England and Ravensbourne. Others, such as Kingston University, have once again submitted films after missing the competition last year, as lecturers and students realise that winning the competition can lead to employment for the students as well as publicity for their courses.

The University Trophy, awarded to the highest scoring portfolio of films across different genres, is highly valued as an indicator of the quality of teaching at that faculty. Steve Whitford, Course Leader, BA Film Production (BAFP) at Portsmouth said: "We are very honoured to have received this prestigious University Award. It affirms what our staff strive for in our teaching: to aspire to an industry level. It also affirms what we know: that students from our BAFP course are producing industry-level work. This Award recognises these achievements and puts the course on the Cinematography 'map' of top Film Production universities in the UK."

Krister Antonsen, who won last year, has returned to his native Norway after his work experience in Birmingham and at The London Studios, where he worked on *The Graham Norton Show* and *Loose Women*. Runner-up, Alex Lines, says his work experience placement boosted his confidence and led to a successful job interview with Transmission TX. Alex said: "I'm certainly not underestimating how much the GTC connection helped me out."

GTC members who would like to attend the Awards presentation evening should contact Alan Duxbury (alan.duxbury@gtc.org.uk) for tickets.