From Ropes to WiFi

The surprising story of stage lighting control

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See a video recording of the lecture here: https://tv.theiet.org/?videoid=18055

Good afternoon everyone.

In my talk this afternoon I'll be guiding you through the curious history of how stage lighting has been controlled, stopping off at a few places to look at some interesting techniques and technologies.

I want to begin when theatre first comes indoors with the religious plays in churches during the Middle Ages, lit by candles and oil lamps.

This woodcut shows the scene of the Annunciation, when the Archangel Gabriel comes down to see Mary to tell her that she will bear the infant Jesus. The woodcut shows not only the biblical story, but actually a performance acting out of that story. And if we look at the woodcut, we see Gabriel front left, Mary front right, and behind three angels suspended between heaven and earth.

If we look carefully at the Dome that represents heaven, which is a typical medieval way of representing the heavens - as a dome - they are suspended on a rope or a chain. So it doesn't just show the imagined scene, it shows a theatrical presentation of the scene.

We need to introduce here the idea of the mandola. Mandola means almond. So we think about the shape of the almond and it can refer to the divine light that surrounds holy characters; we see that with the centre of the three angels, the light radiating out from this almond shape.

But mandola can also mean the metal frame that is used for raising and lowering a person, and so we imagine these three angels as performers being raised and lowered on a metal frame with these little clouds that were probably made out of wool or something.

In his book *The Lives of the Most Excellent Painters, Sculptors and Architects*, Giorgio Vasari describes Filippo Brunelleschi's mechanisms for a performance of the *Annunciation* in the Church of San Felice in the 1430s, And he writes,

> Eight angels were lowered from the space within the half globe. In the midst of this cluster of eight angels was a mandola of copper hollow, within wherein were many holes showing certain little lamps fixed on iron bars in the form of tubes. Which lamps on the touching of a spring which could be pressed down were all hidden within the mandola, whereas when the spring was not pressed down, all the lamps could be seen alight through some holes therein.

So there we are - in the middle of the 15th century, we have perhaps the first ever record of *lighting control*.

We move forward.

The Renaissance court theatres of Italy were part of, and the performances in them were part of, great festivals within which light was enormously important. These festivals typically marked the births and marriages of the nobility and the visits of neighbouring Dukes and Princes.

Temporary stages initially were built within the halls of palaces and later in purpose-built theatres. This particular one is the Castle Theatre, Český Krumlov, in the south part of the Czech Republic. Český

Krumlov is a little bit later, 1680, than the very first [indoor] theatres, but it gives you an idea of the kind of theatre we're talking about.

Nicola Sabbattini, who was an architect but was very involved in the construction and operation of theatres from a sort of technical point of view, wrote a book.


PRATICA
DI FABRICAR SCENE,
E MACHINE NE' TEATRI
DI NICOLA SABBATTINI
DA PESARO
Già Architetto del Sereniſſimo Duca Franceſco Maria Feltrio della Rouere
Vltimo Signore di Peſaro.
Riſtampata di nouo coll' Aggiunta del
Secondo Libro.
All' Illuſtriſſ. e Reuerendiſſ. Sig. Monſig.
HONORATO VISCONTI
Arciueſcouo di Lariſſa della Prouincia di Romagna,
& Eſſarcato di Rauenna Preſidente.
CON PRIVILEGIO.
Libro di mé Antonio
Canaleri dei Flaminj
In RAVENNA, Per Pietro de' Paoli, e Gio. Battiſta Giouannelli
Stampatori Camerali 1638. Con licenza de' Superiori.

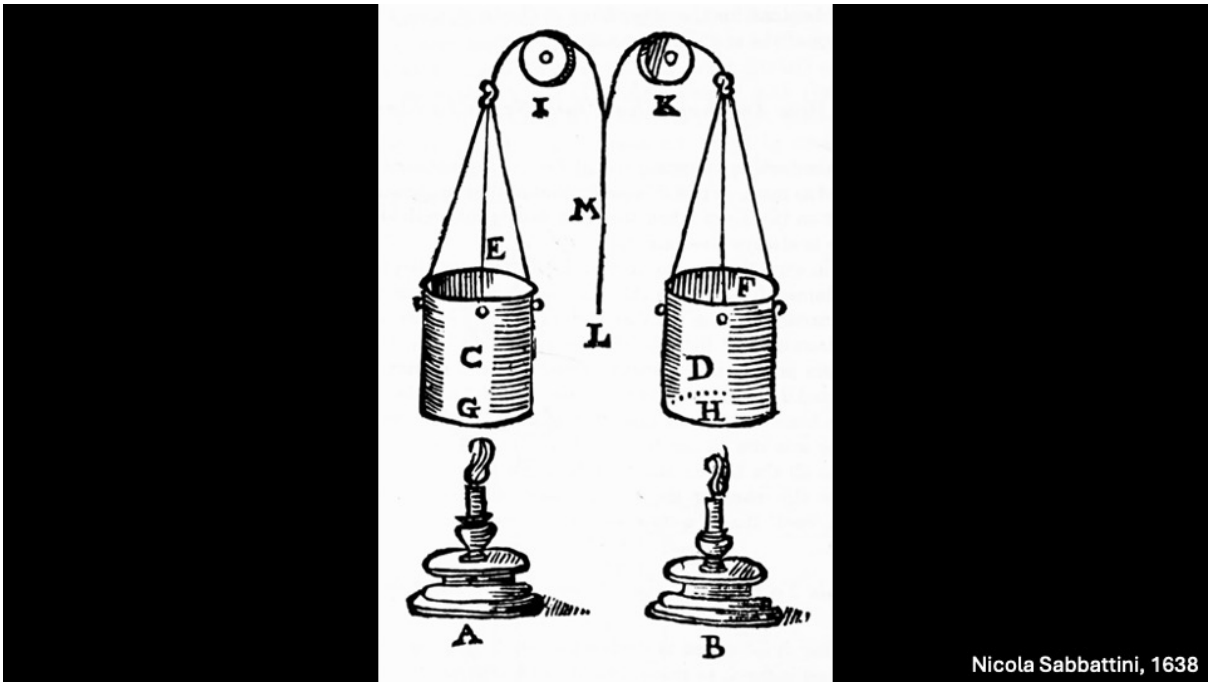
In the book he gives detailed instructions of how to stage theatre performances, and he explains something about lighting. He says that you need to place lamps in the auditorium (in those days, the expectation was that the auditorium remains lit throughout the performance), behind the proscenium to light the heavens and the scenery above the stage, and in the wings, and also Footlights - although Sabbattini is rather scathing about footlights saying they cause ugly shadows and aren't such a great idea.

Sabbattini recognises one of the great control challenges is that you've got to light your light sources in the first place - candles and oil lamps. And that's a challenge because you can't do it too far ahead of the performance because a candle will only last a certain length of time and an oil lamp similarly will run out of oil.

So he proposes 3 methods of overcoming this difficulty - and he's particularly thinking about chandeliers or lights raised up above floor level. He says you can have a fuse that connects all the candles in the chandelier. But he writes, often the flames go out before they reach the candles and other times as the fire follows the flaxen wicks, these sometimes divide and burning pieces of flax fall down causing damage and “general confusion”.

So he says the second method that you can use is to get a really long pole and put a little candle on the end of it and use that as a lighter. And then finally, he says the third method is to lower the chandelier and light it in a normal way, which perhaps might be the best bet after all.

Sabbattini also gives us this drawing:



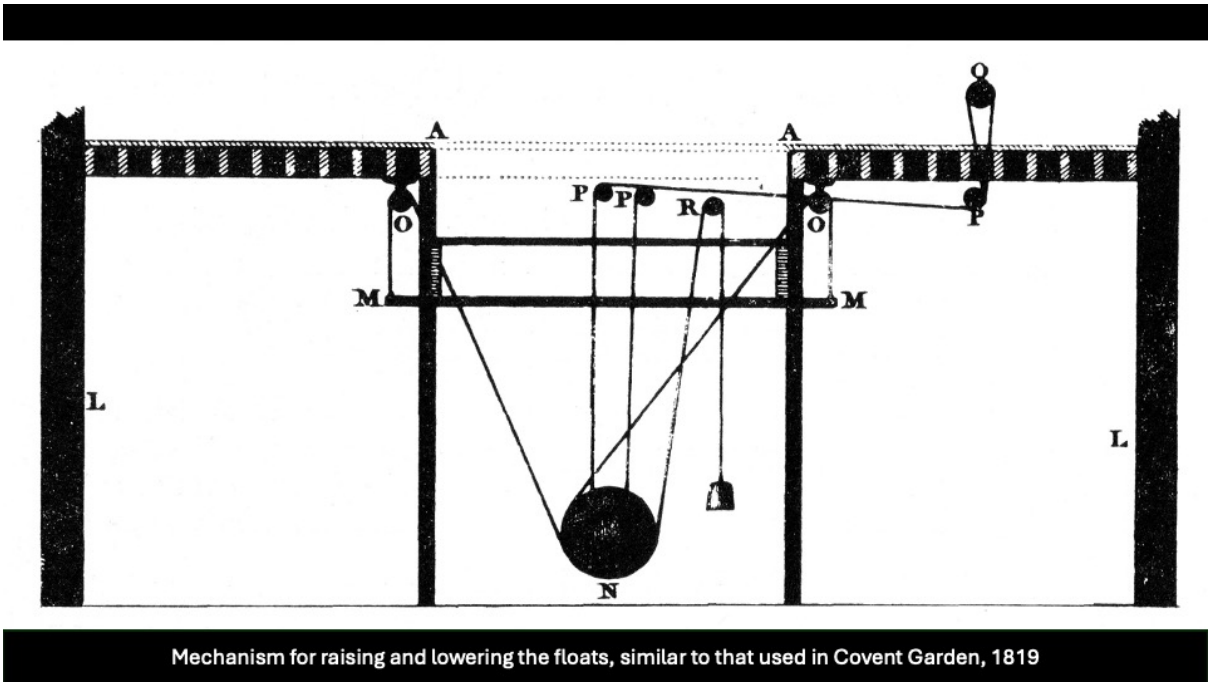
There aren't very many pictures in this book, and the ones there are, are mostly diagrams. He explains at great length what all the little letters mean, but I think we can work out for ourselves what's going on here: some little tubes made of tin, which can be lowered down to hide the light of a candle or an oil lamp. The tube is open at the top so the air can still flow through, so you don't put the light out - it's not there to snuff the candle.

Joseph Furttenbach, who wrote similarly about stage technology a little bit later in 1663, described exactly the same system. He writes,

> The cord from each lamp is led up above the stage, thence to a single handle for all the cords. When this handle is forward, the lamps shine as for a bright day. But when the handle is drawn back, then each cap covers its oil lamp so that not a ray is seen. This effect gives great delight to those who see it.

We can imagine, for a world where candle and oil lamps were the everyday light source that everybody would have been completely familiar with, when on a stage setting all of the lamps are hidden behind the scenery, so we can't actually directly see them, and the mechanism that's being described is also hidden, the idea that the light should just slowly disappear and then reappear without any apparent mechanism to do that must have been a truly extraordinary and wonderful - and indeed delightful, as Furtenbach writes - effect.

I'm going to press on, we've got a lot to get through.

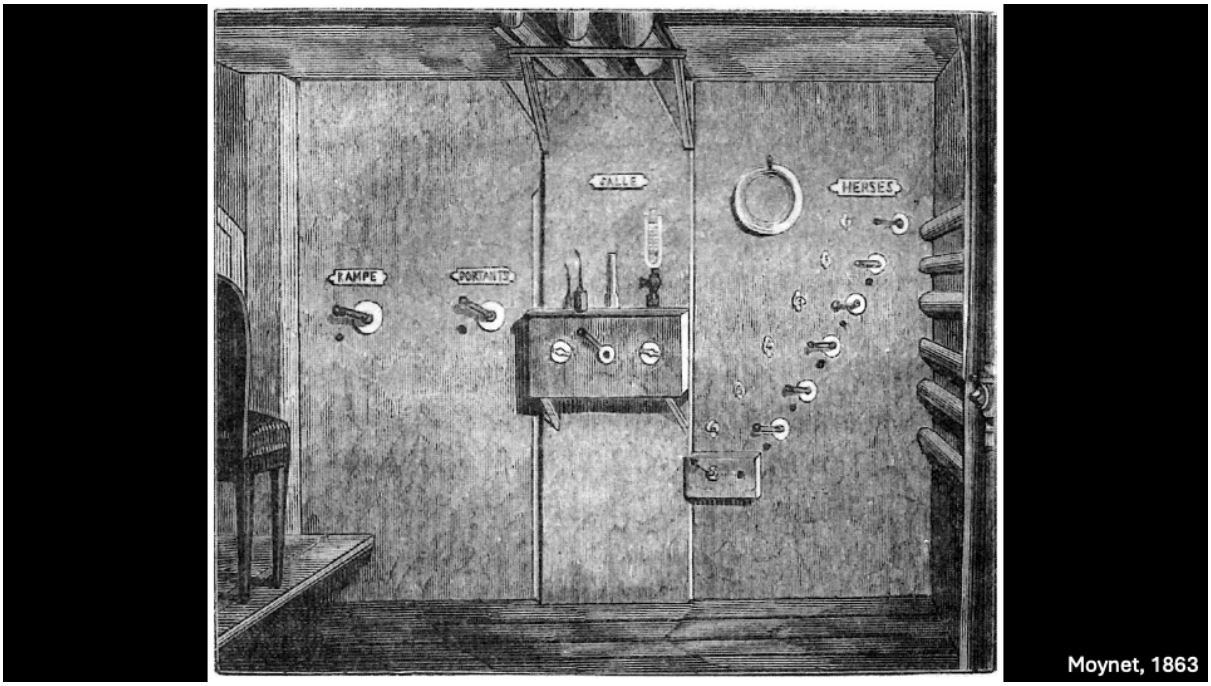


Mechanism for raising and lowering the floats, similar to that used in Covent Garden, 1819

This diagram from 1819 shows how we can mechanise the way that we introduce light into the stage space. It is a front-view cross-section of the stage. The stage floor is at the top of the diagram, and this is a mechanism that allows us to raise and lower the footlights through a slot in the front of the stage. There's a platform that goes from M to M in the diagram, pulleys O take ropes that go down to the drum at the bottom centre N. We imagine turning that drum and either pulling or lowering down the ropes, thereby raising and lowering the platform. And then there's a control line that goes through the pulleys P that takes up to a point above the stage Q. And there's probably a handle or something there, so you wind that handle, that winds the drum, and that raises and lowers the Footlights. As you can see, there's a counterweight there, so we don't have to take the weight of the whole mechanism, we only have to overcome the friction in the system. And this means now we can effectively dim the Footlights because as they drop below the stage, of course they stop lighting the stage. And it also means we can access the Footlights in order to trim the wicks of the candles or refill the oil lamps or whatever.

That brings us to the early 19th century which brings a huge change, the introduction of gas lighting. In 1803 Frederick Windsor set up an apparatus on the stage of the Lyceum Theatre, not all that far from here, in order to promote the new gas light, the new way of lighting using gas, and it was adopted fairly rapidly by theatres. By 1829, all but one of the main theatres in London have some gas lighting.

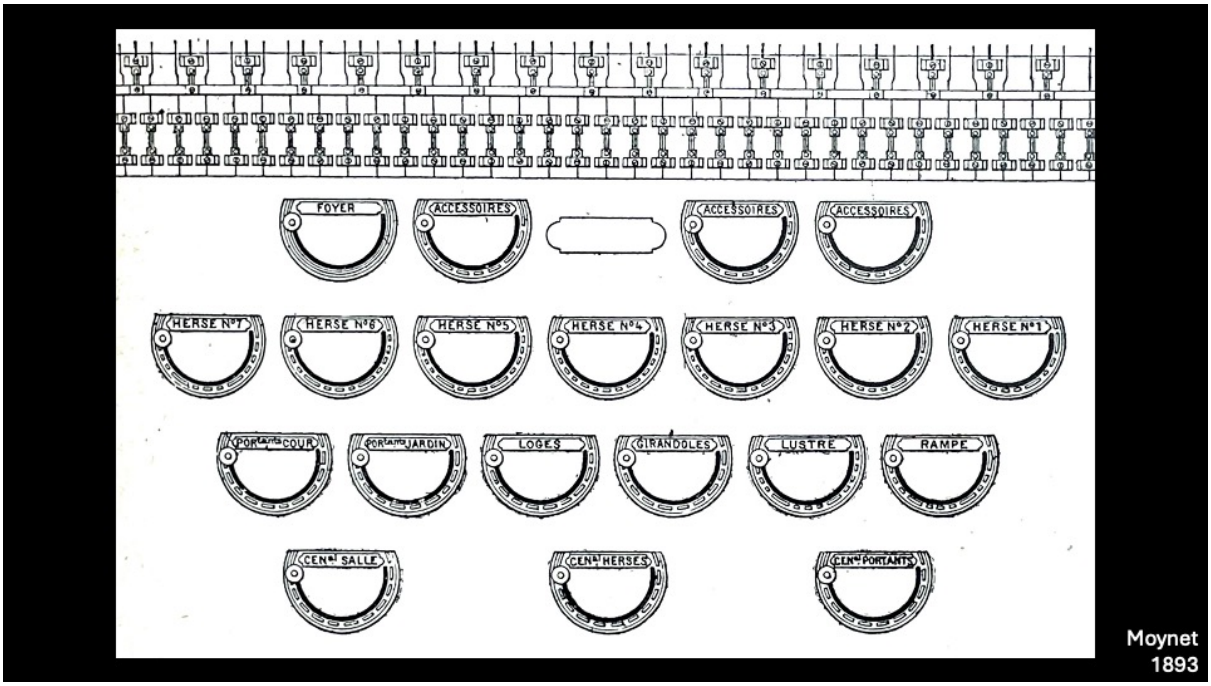
It was usually introduced in stages, it's not completely relighting the entire theatre, so for quite a long time there's usually a combination of gas lighting and the older oil and candle mechanisms. Gas lighting brings a tremendous advantage from a control point of view, and it's this - the gas table.



The gas table really is a point where a whole series of gas taps are arranged, where they can all be accessed together. The gas taps are in the pipes that feed gas out to the burners in different parts of the stage and indeed the auditorium and potentially the backstage and front of house areas as well.

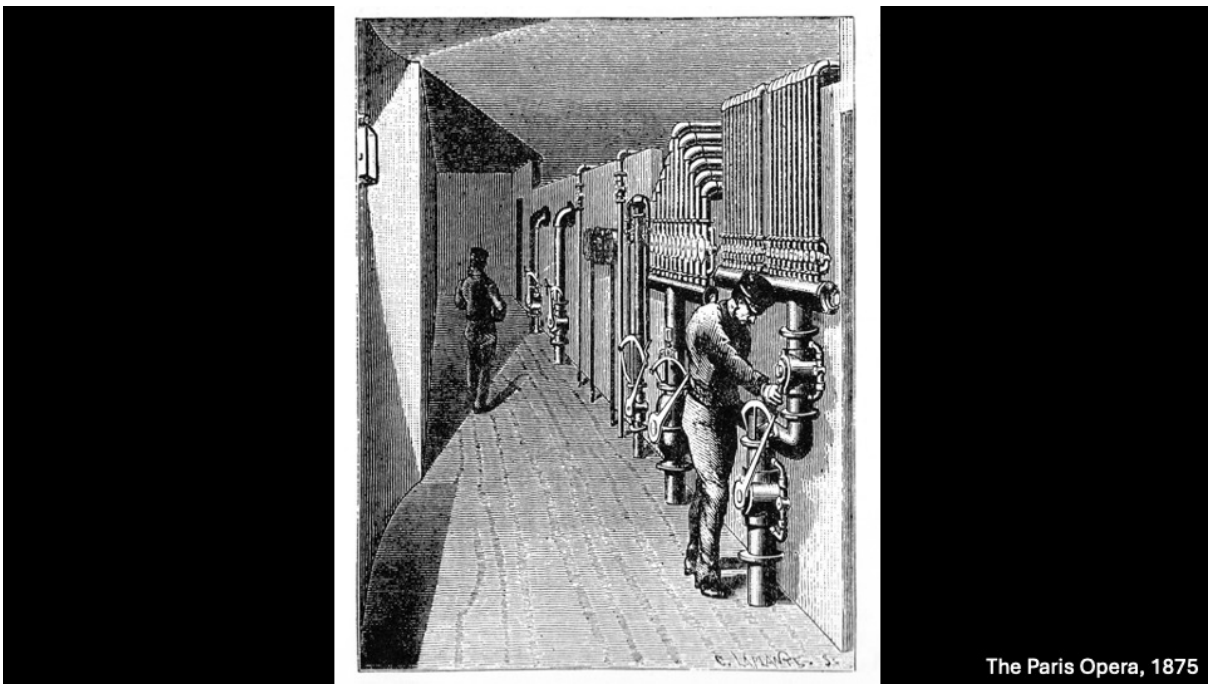
This is a French example published in a book by Moynet in 1863. We have here the *rampe* - the footlights; the *portants*, which are the lights in the wings; the *salle* - the front of house lighting; and the *herses*, which are the lights above the stage. And they're split into six different sections.

So now one person by operating the valves can have quite a sophisticated level of control over the stage lighting. The gas table is usually placed adjacent to the side of the stage next to the prompt desk, where the prompter sits, who is the person who manages the whole performance and gives the cues and and keeps the performance running in the correct way. The gas man then works to the orders of the prompter.



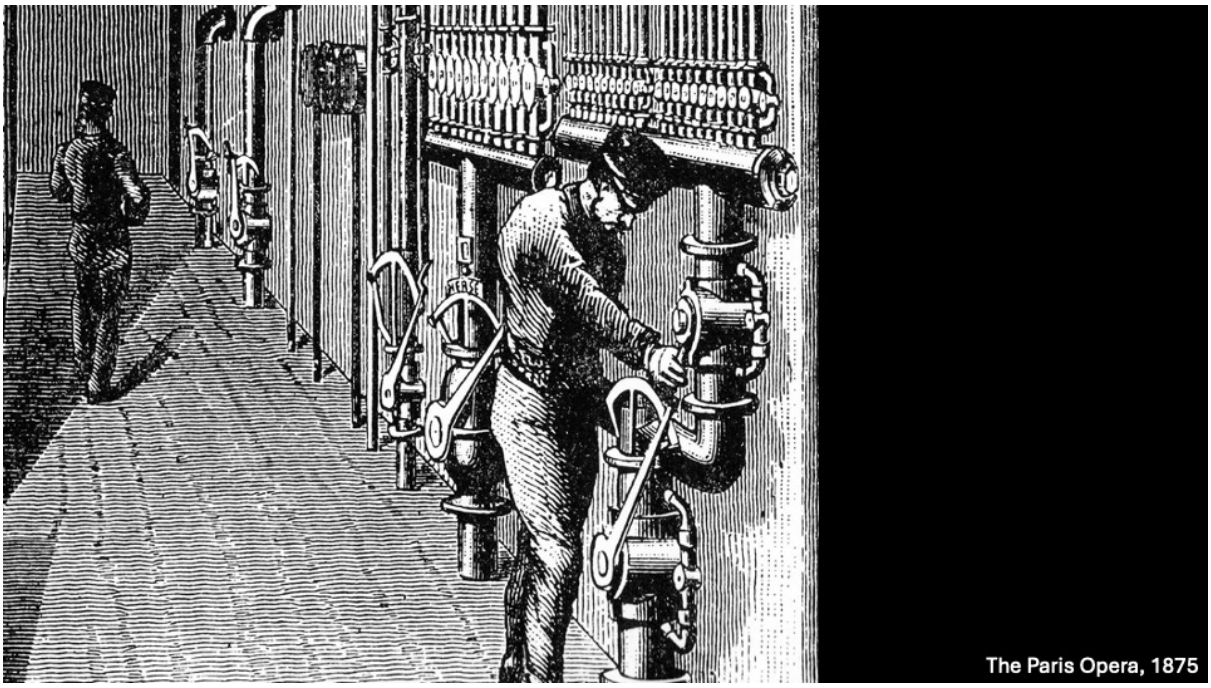
Here is a second example of a gas table, and we have a slightly greater level of sophistication in that the different areas of the auditorium now are split into several different sections which can be individually controlled. And really importantly from a control point of view, we have what those of us in the lighting world will call *mastering*. The three handles at the bottom control the auditorium and all of the circuits in the auditorium, the overhead lighting and the wing lighting separately. So now we can adjust the levels of the seven groups of overhead gas lights and control them all together. We can set a balance of lighting, or which ones we want on which ones we want off, and then control them all together rather than trying to run around doing them all individually.

We have now introduced the idea of quite smooth changes of light, even though we've got the sophistication of breaking our light down into quite a few different areas within the theatre.



This is the gas table of the Paris Opera installed in 1875.

This brings another particularly important feature. I was talking just now about Sabbattini's views on how you light the candles. Well, you have the same problem, of course, with gas lighting: how do you get it started? And more importantly, if you want to dim the light down, how do you relight the gas burners during the performance?



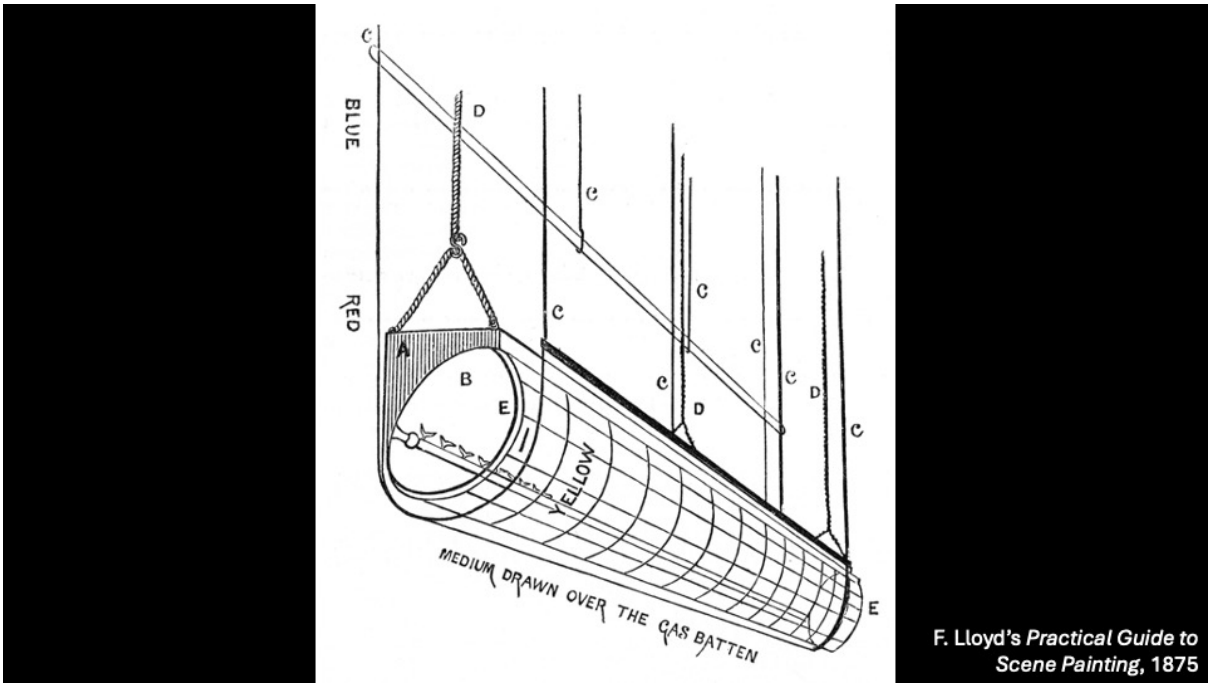
If we zoom in on this picture, you'll notice that all of the valves – the big valves on the bottom, and then the smaller valves going off from there – all have a small pipe That is a bypass pipe, that takes a

small amount of gas around the side of the valve. So now by adjusting the tiny valve that's in the bypass pipe, we can determine how much gas is continuously flowing.

When you turn the main valve down, a small amount of gas continues to flow and the burner doesn't go quite out. Now we have the possibility of dimming our lights effectively down to black, although they don't quite go completely to black, and bringing them back up again during the performance.

There's of course an alternative way of doing it, which is the pilot light, where you have small pipes running little burners adjacent to each main burner, which again are continuously burning throughout the performance.

There were some attempts at automatic ignition of gas, including electrical systems to do that, none of which really was successful or caught on.

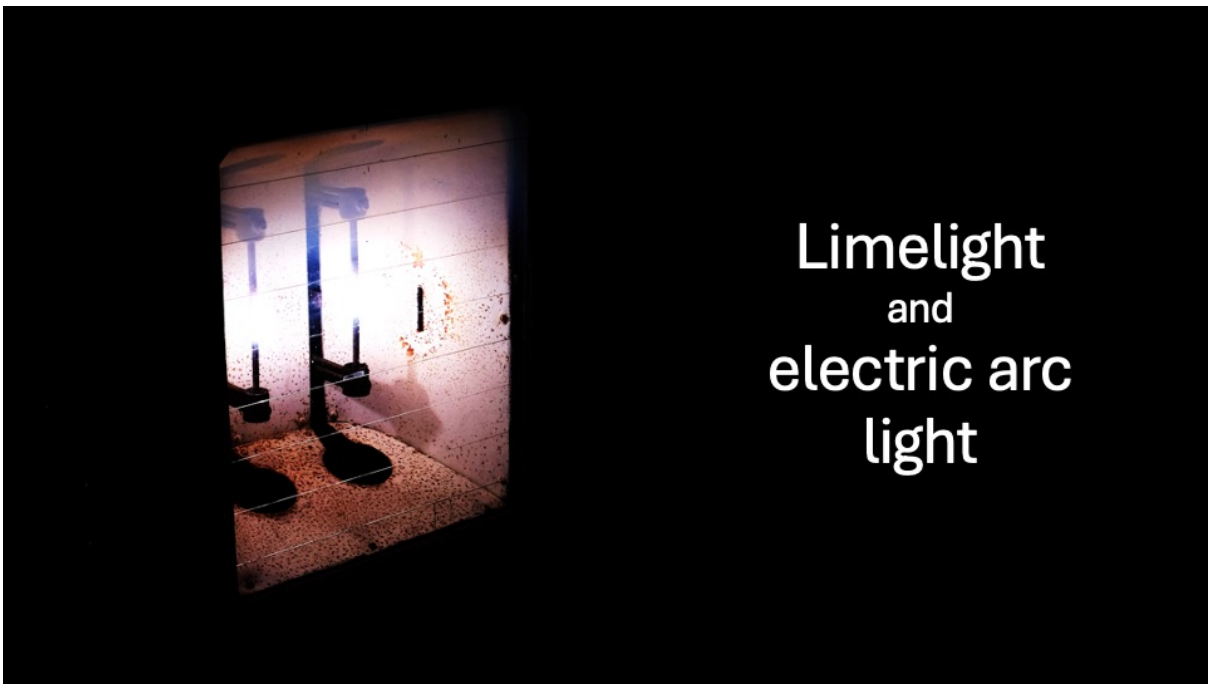


F. Lloyd's *Practical Guide to Scene Painting*, 1875

So far I've only really been talking about the control of the brightness of our light sources. This is an example of a what's called a gas baton, that's over the stage - the length of it runs across the width of the stage, pointing light down onto the stage - which has colour control. We see here the baton with it's pipe with little burners and a curved reflector to bounce the light down onto the stage, to concentrate it onto the stage.

In front of that there is draped what is called here the *medium*, the colour medium, which is probably coloured silk or something like that, in strips of colour. In the illustration it's shown that the yellow is in front of the lights and attached to that going up behind the lights, a strip of red and then a strip of blue.

By lowering the ropes on one side of the colour medium and pulling it up on the other side, we can kind of roll the colour medium around the front of the lights and introduce different colours into the lighting. The order of the colours is no coincidence; it goes from yellow to red to blue, because we can go then from open white - the natural colour of the gas flame - we can then add the yellow, we can add the red and we can add the blue. So we can do a sunset by continuously moving through the colours.



I'm going to briefly talk about Limelight and electric arc lights, which both come in during the 19th century - they're enormously important to theatre lighting but they're less important to theatre lighting control. And I'm going to tell you why.

Gaslight gives this fantastic amount of control that we've talked about relatively easily. It's pretty straightforward to make the gas taps and the pipe work and everything, but gas still involves a very large number of relatively dim light sources. Each burner is not all that bright; it's a bit better than oil and candle, but it's not that bright. The limelight and the electric arc light both give you an intensely bright source, so now we can have a beam of light coming from a single source. That's hugely important for stage lighting - it shaped the way that stage lighting is still done.

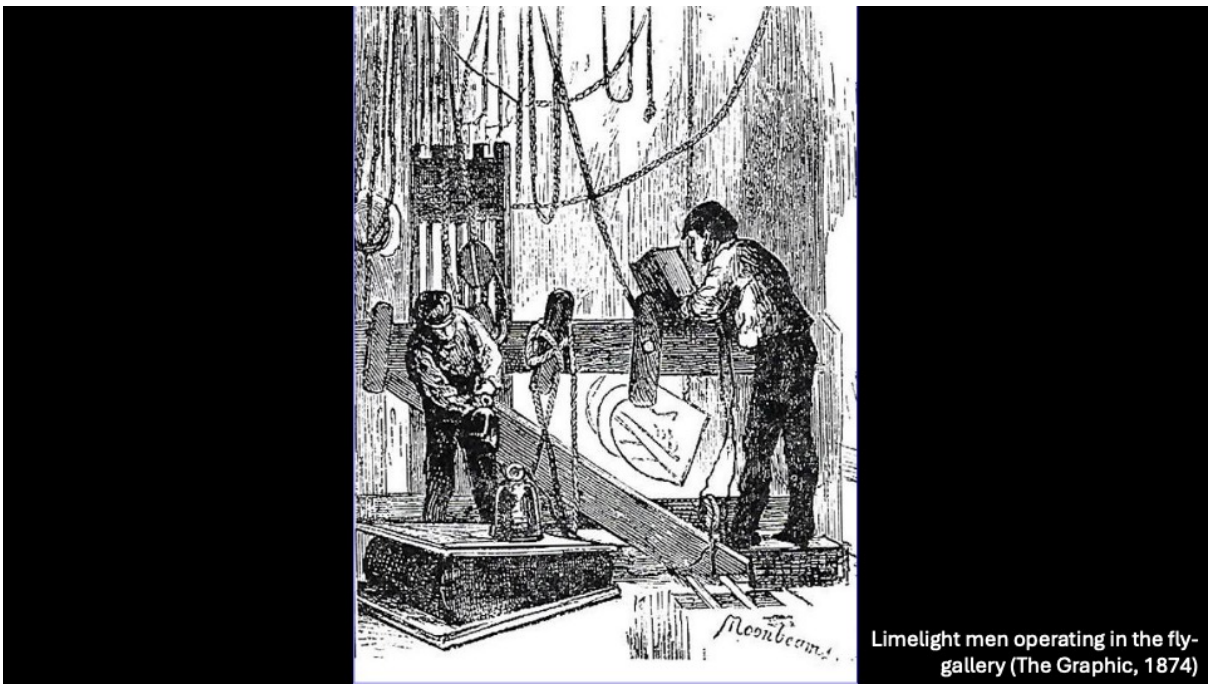
Now we do almost all of our stage lighting with spotlights - something that produces a narrow, focused beam of light - and it started in the 1830s with limelight, which is produced using an oxyhydrogen flame.

Just think about that: leather bags of oxygen, bags of hydrogen being carried around in the theatre. They are actually made in the theatre because there isn't BOC, able to send a lorry with some canisters of gas in. Used to heat a block of calcium oxide quick lime and that produces an intense white light.

And although the technology is very different in some ways, the carbon arc is where you pass a current through two pieces of carbon rod that have a small gap in between them so you get an arc, a spark that jumps between them and sits there continuously and produces a very bright light source.

And again, early on, the theatres were building their own batteries in the basement or an adjacent building or wherever you could find a space to generate the electricity. A bit later on, the 1860s, you get steam generators to do that work, and later still, of course, public electricity supplies can do it.

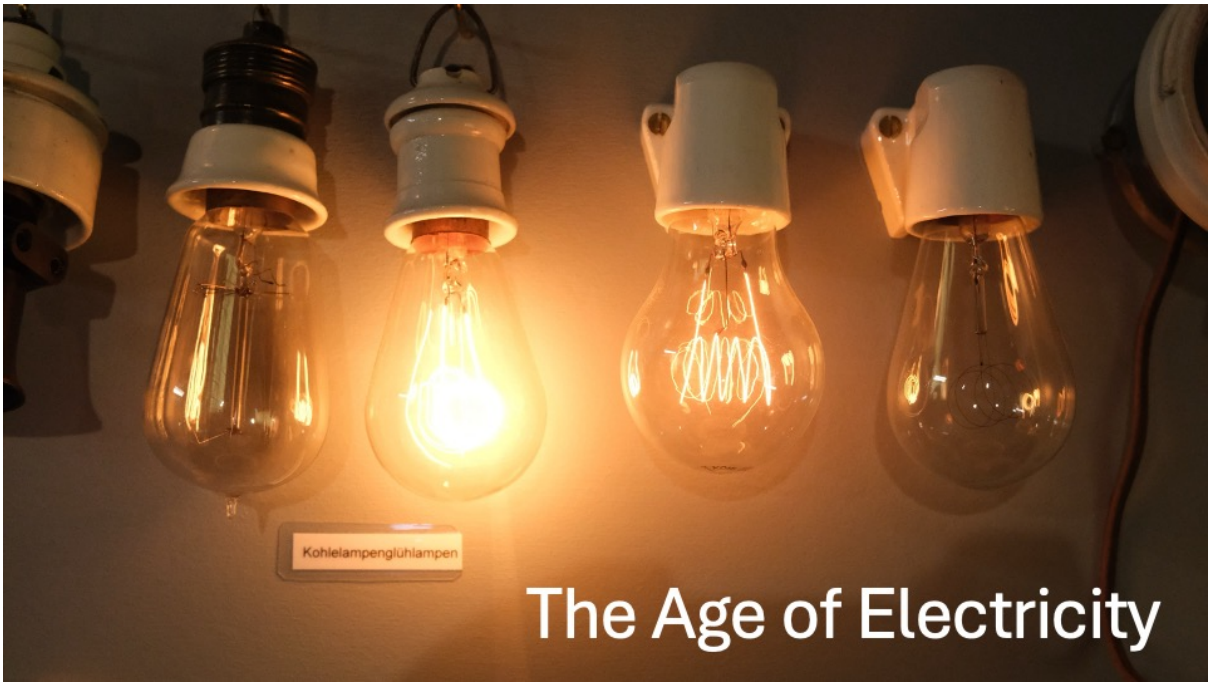
In both cases, at least to begin with, they need an operator to manipulate them, and that limits where you can put them. It has to be somewhere in the theatre where an operator can get to them - they need continuous attention.



We see in the picture here of the limelight, the Limelight operator's assistant putting weights onto the bag, which is probably a leather bag or something like that, in order to maintain the gas pressure as the amount of gas in the bag diminishes.

Later on, carbon arc gets really quite sophisticated, with either electrical or clockwork mechanisms to move the carbon rods together to maintain a constant gap; the partial ability to dim as well (they can't really dim it all the way out); automatic relighting when it does go out, that kind of thing.

But in terms of control, our next big thing is inevitably the real age of electricity.

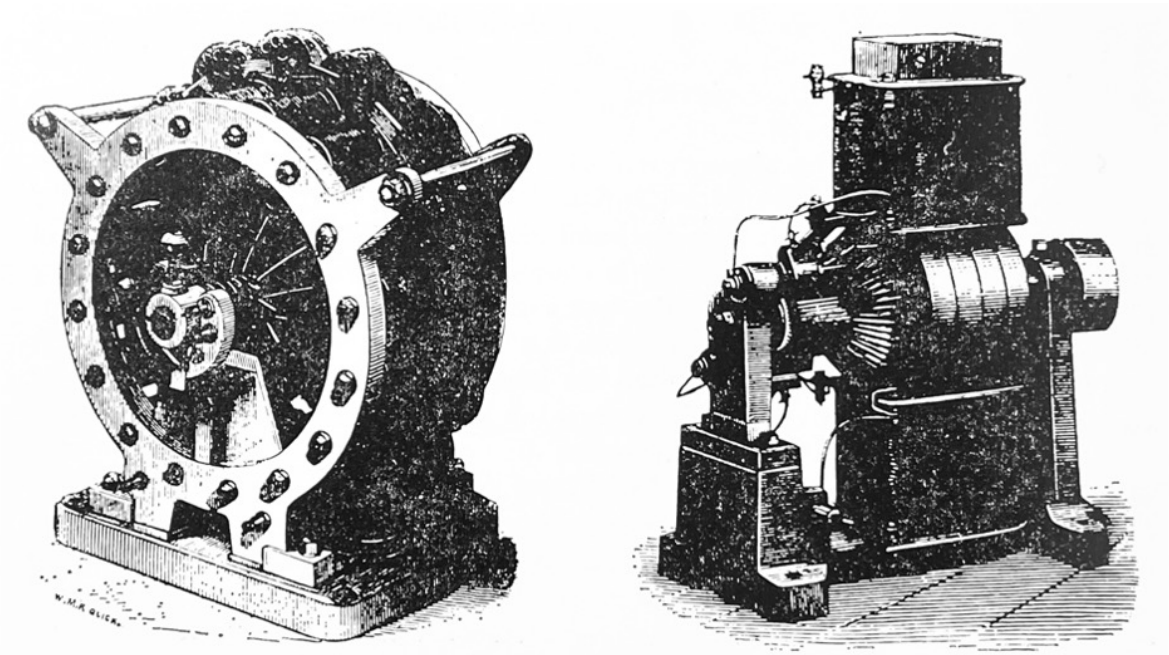


In 1879, Thomas Edison in the USA and Joseph Swan in the UK both develop a working carbon filament lamp, the light bulb as we may be currently think of it. Carbon arc has been around for 30 years as an electric light source, but this is what really makes electric lighting possible. And it's an incredibly rapid transition to electric lighting, mainly driven by safety. Gas was phenomenally dangerous. Hundreds, probably if you add it up across the UK, the United States, Europe, probably thousands of people died in fires in theatres because of the gas light and many theatres were burnt down and destroyed and had to be rebuilt.

So electricity is hugely attractive from that point of view. It doesn't change lighting very much to begin with because the light bulb isn't really any brighter than the gas burner. So really you're putting in light bulbs in pretty much the same places around the theatre where you had a gas burner before. But it raises the question of control again: what's the electrical equivalent of the gas tap?

In 1881, only two years after Swan and Edison, the Savoy Theatre, again not all that far from here, was the first theatre to be fully lit by electricity. Not only the first theatre, the first public building anywhere in the world to be fully lit by electricity. It did though have a gas backup system, so new is the technology, which was just as well because it was several months after it first opened before they had all the electrics working in the way intended. But by the end of 1881, we have our first electric lighting system and then it, as I say, very rapidly catches on elsewhere.

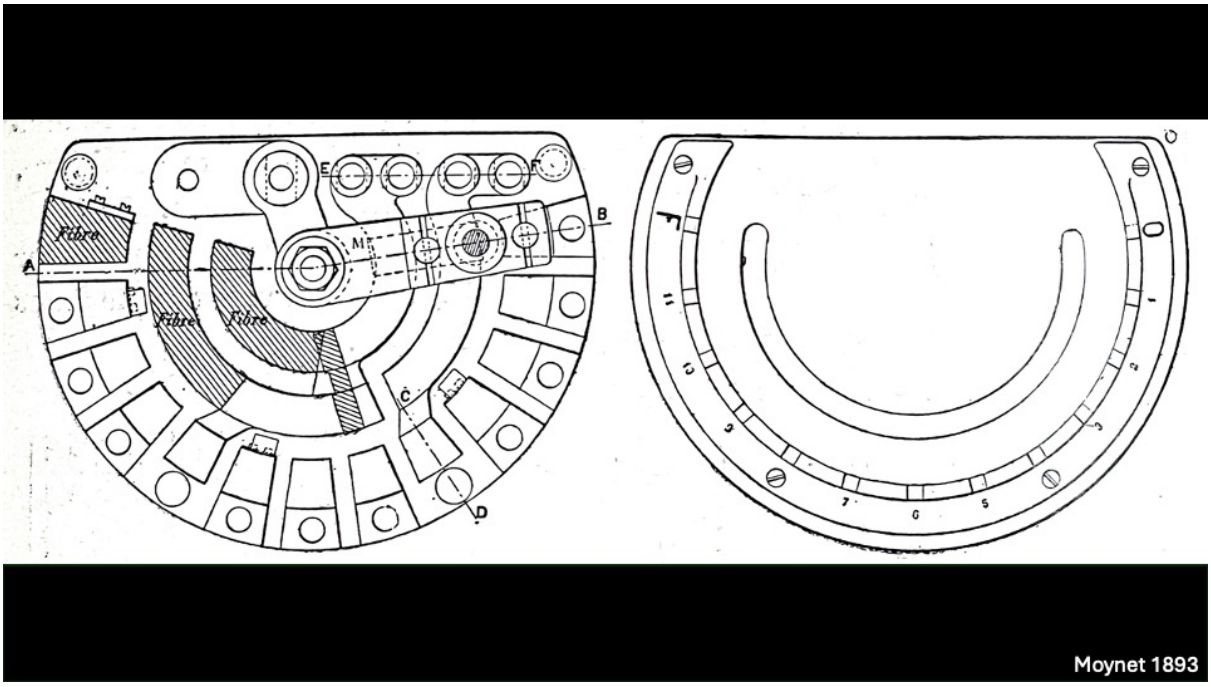
There were 1200 lamps around the building foyer, stage, auditorium, and from a control point of view, a rather interesting setup in that the power required for the six circuits of lighting came from generators - AC alternating current generators provided by Siemens, the field windings of which were powered by DC dynamos, both driven by several steam engines.



Siemens W_1 alternate current machine and dynamo-electric machine, *Engineering*, 33 (1882), 206

So 6 pairs of generators and dynamos and a quite ingenious, I think, way of dimming the lighting. You could put resistances into the main circuit, but it's tremendously wasteful. Instead they put resistances into the field winding circuit, so you reduce the strength of the magnetic field in the generator and therefore reduce its output. There was a six step controller, so 6 steps between off and fully on - in some ways a step back really from gas, at least to begin with.

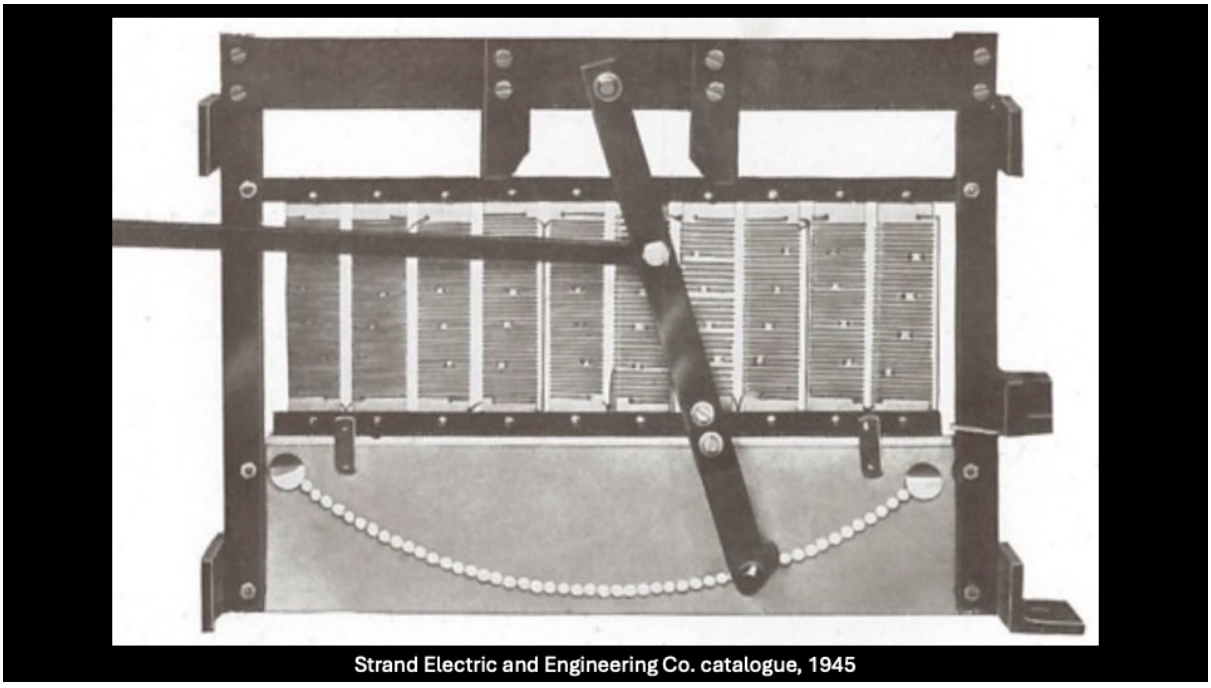
This was certainly an ingenious system. It's an awkward system though because it's not terribly scalable, because if you want more circuits of lighting, that means more generators and more dynamos - it all gets rather unwieldy. And certainly once you move to public electricity supplies and you're not generating your own, of course, then all that goes out the window.



This is a dimmer from an 1893 publication. We've got in the two parts of this drawing. On the left is, you can imagine a rotating switch, that makes contact with all the various contacts in an arc around the bottom. Each of those is connected to a different resistance that is therefore switched into the circuit and dims the lighting attached to it. The right-hand half is particularly interesting for lighting control geeks like myself: it's the faceplate, what the operator would actually see.

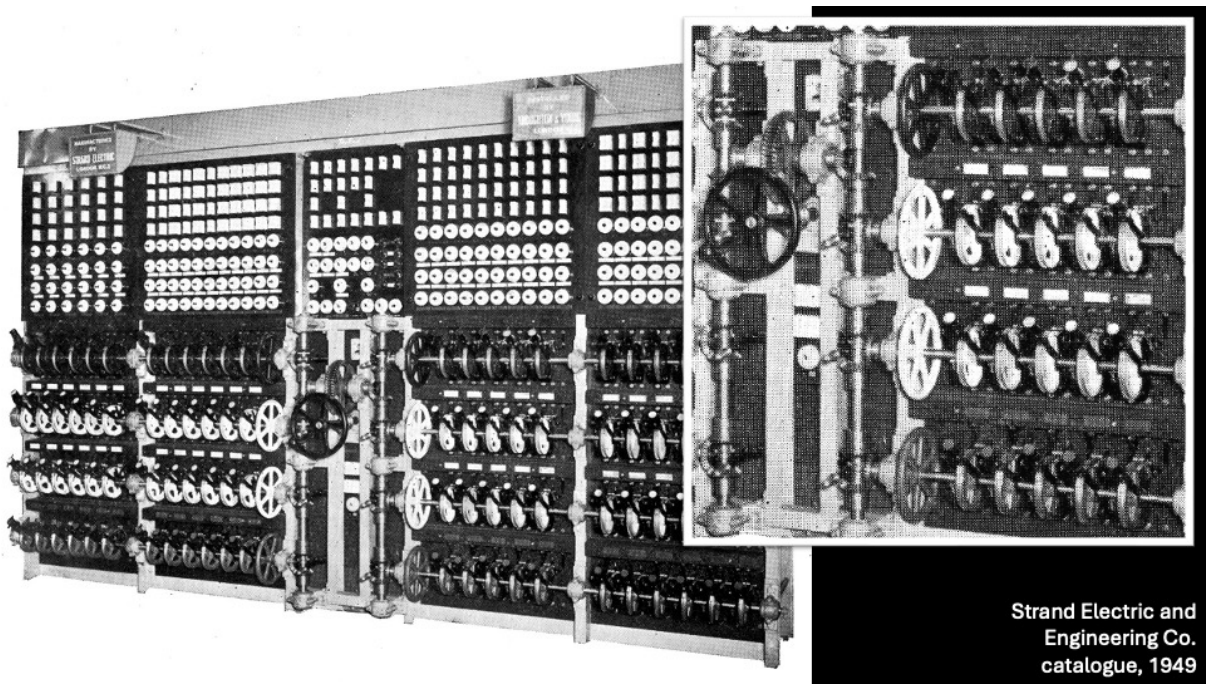
And don't be fooled by the F, this is French, so the F does not mean full, as scale goes from O to F, O being full, F being off completely. And a numerical scale that goes from 1 to 11. So it's a 13 point scale where one is the smallest amount of dimming.

It's upside down to what we're used to now because it seems to me the mindset comes from a situation where we start with the assumption that the lights are on and then we decide we want to dim them. Today, we do the complete opposite - we start with the assumption the stage is black and we add the lighting that we want, and therefore all of our scales now go from nought to full. We *add* lighting: how much light do you want? You want 20% of light, 30%, 70% up to 100% full.


Strand Electric and Engineering Co. catalogue, 1945

This idea of the resistance dimmer continues to be developed, and this is an example from Strand's 1945 catalogue, and you can see here fairly straightforwardly how it works. There are some wire windings which have tapping points. They're all connected to the little studs in an arc on the bottom. You can imagine pulling or pushing the lever from the left hand side, so we pick up a different amount of resistance to put into the circuit.

So far, so straightforward. But what moves the little lever that that operates the thing? Well, something like this.



Just to give you a sense of scale, one of these is probably something like 8 or so feet tall. It's a big old lump of mechanical equipment. There is nothing electrical about this or electronic, certainly not electronic, nothing electrical about it apart from the dimmers themselves. It's a mechanical system.

And my little zoom in on the picture there, I can briefly explain how this works. Each dimmer is attached to one of the levers, which has a wheel with it. So you can see the wheel and the little round end of the lever - you can waggle the lever and that will move the dimmer.

You can use a kind of clutch to lock the lever to the wheel, and the wheel is attached to the shaft. The shaft has a bigger wheel at the end of it, so now I can group some lights together. I turn the bigger wheel and all of those dimmers move, so I can coordinate a group of lights to move together.

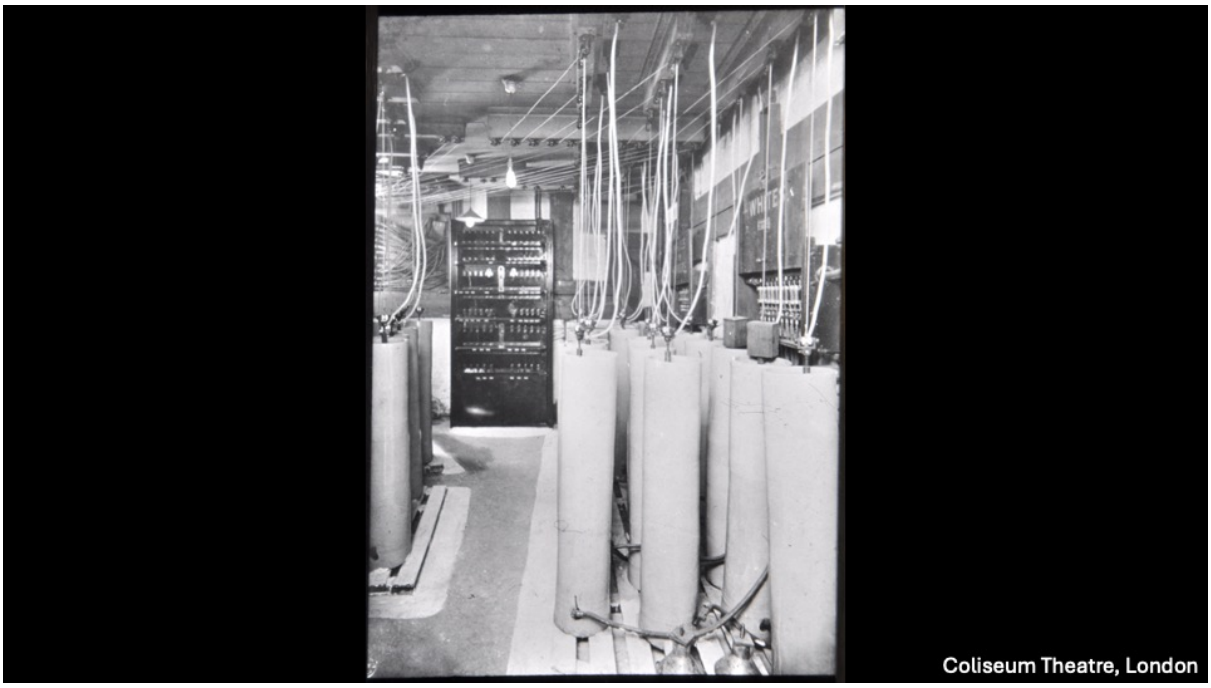
The middle size wheels are connected to the big wheel in the middle by some more gears. So now I can turn the really big wheel and move whichever lights I've selected to change. And because of the way the clutches work, I can choose whether the individual shafts move in the same direction as the master wheel or in the opposite direction. So now I can turn the wheel and some lights are fading up and some lights are fading down, and I have a ‘cross fade’, in the jargon – I can smoothly replace one lighting state with another.

You're probably ahead of me in spotting some of the limitations here. Any dimmers that are on the same shaft can only ever move in the same direction. If a dimmer is already, say, at 50% and I move it up, it will arrive at full before a dimmer on the same shaft that starts at 0. It will only have got to halfway by the time the other dimmer has got to full. There's an ingenious clutch mechanism that releases it from the wheel when it gets there so you can keep turning the shaft. The system doesn't mechanically jam up, but it means we have something called broomstick mastering rather than proportional mastering.

Proportional mastering is mostly what you want, which is where all of the dimmers take the same time to move to their final level, irrespective of how far they're moving – that gives you a nice clean looking fade. This doesn't. If you imagine you had some lights and you're going to black out at the end of the scene, the lights that are at full will get to black last. The lights there are intermediate levels will get to black first. So your lights go down, but you get this raggy kind of different lights dropping out at different points in the fade. And sometimes you can use that to your advantage, but mostly not.

The other practical disadvantage, of course, is these resistance dimmers are producing huge amount of heat. This is a big, heavy, clunky piece of equipment that has to go somewhere in the theatre, and makes the place really hot. You're going to stick it backstage somewhere. The operators almost certainly can't see the stage, so they're working blind. They're just doing whatever they've been told to do, so from an artistic point of view, it's not great.

But let's press on with our thinking about dimmer types.

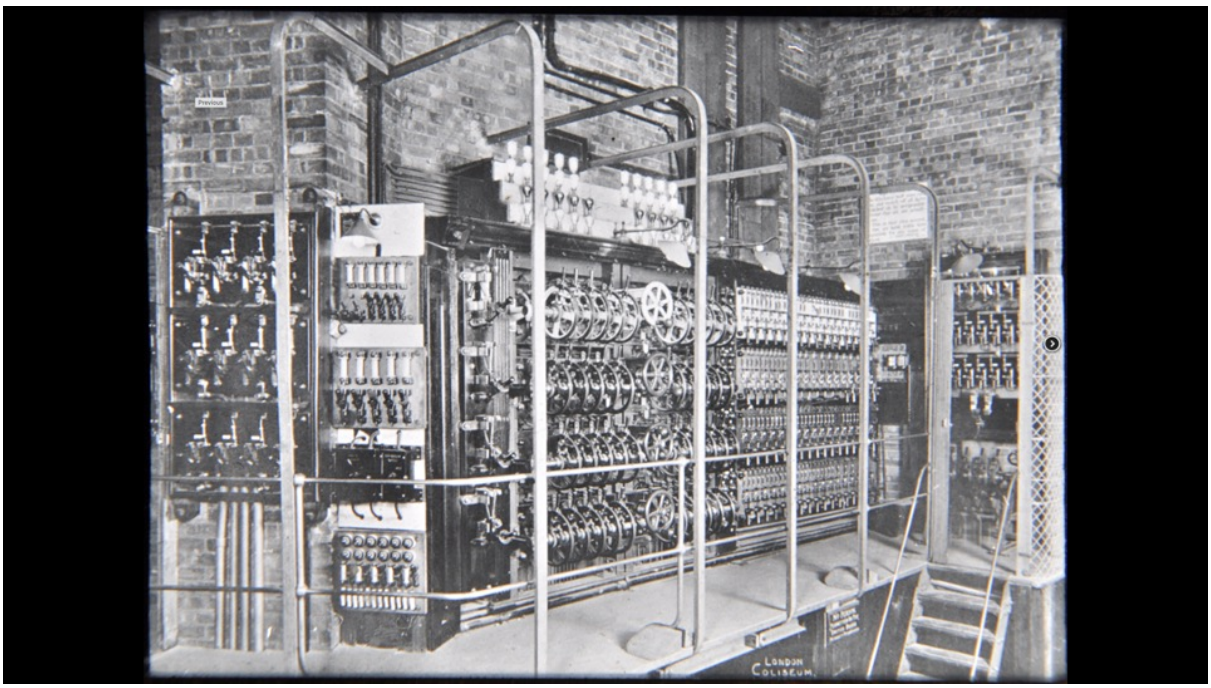


This, as somebody was mentioning at lunchtime, is a saltwater dimmer, also known as a liquid dimmer or an electrolytic dimmer if you want to be really fancy about it.

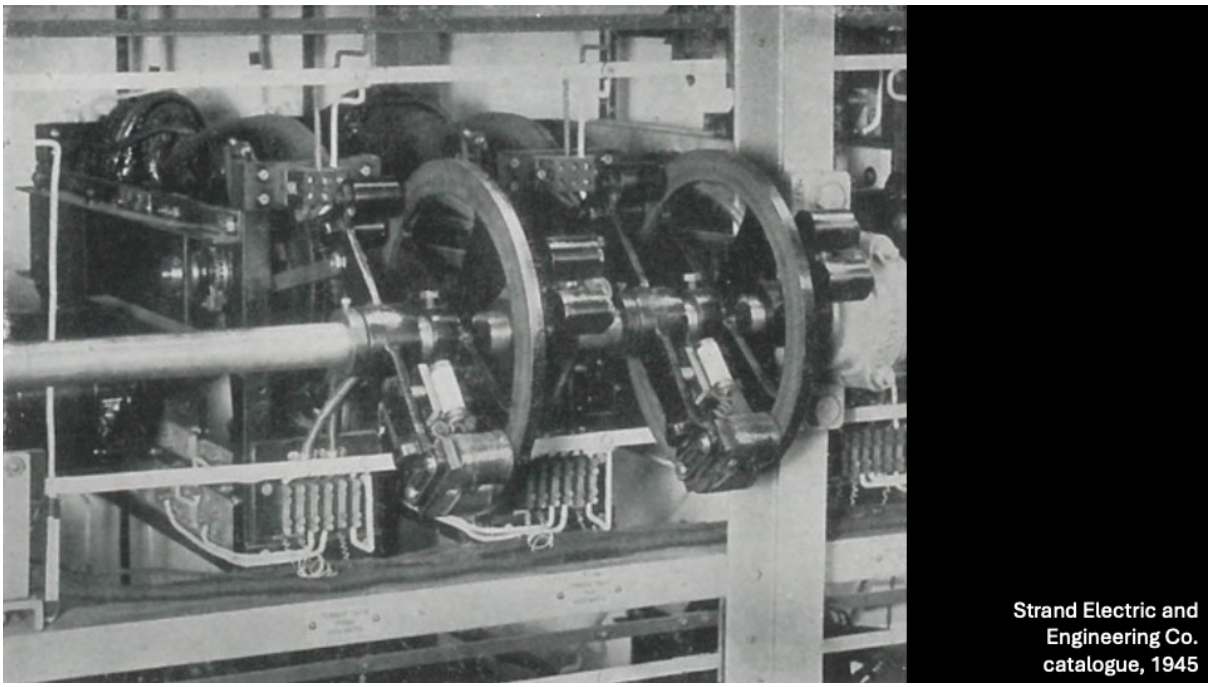
Each of those tubes, which are made of a ceramic of some sort, contains a liquid, which is water and an electrolyte, typically soda crystals, something like that, to reduce the electrical resistance of the water. There is an electrode at the bottom of the tube and there is another one that is lowered in on a wire which is then obviously connected to the circuit.

As you lower the top electrode in, the amount of water between the two electrodes gets smaller, the distance between them gets smaller and your light gets brighter. There were homemade varieties this – perhaps famously, you could do it with a chimney pot and a paving slab. Paving slab at the bottom, cement a chimney pot onto it – build your own.

I have done it not with a chimney pot, but I have done it in a jam jar at low voltage, 12 volts. That's very important because this is all a bit scary stuff really. But this introduces another kind of control mechanism. You'll notice up in the roof of this space, which is probably below the stage somewhere, there are the wires that connect to the control system:



This the Colosseum Theatre again, not very far from here. So a very similar to our resistance dimming setup in terms of the shaft and the wheels, so that from a control point of view it looks quite similar.



Moving on, there are two things in this picture. Firstly, something called an auto transformer that's at the back of the mechanism you see here where you can't really see it terribly clearly. An auto transformer is an electrical winding, rather like an ordinary transformer, and you have taps off the coil, the various points on the winding and you tap off the voltage that you want. So it works essentially in the same way as the resistance dimmer and it's working through the inductance of the coil. It's a lot more expensive, and requires an AC source, which wasn't necessarily the case with public electricity

supplies to begin with. It's still mechanically operated. It has certain technical advantages, but certainly in the UK it didn't ever really catch on, mainly because of its cost.

The front part of the mechanism you see here is quite important from a control point of view. It's a thing called a Mansell clutch. So think about the shaft that's running across the picture that is driven by a motor and turns continuously. The wheel is attached to it, that turns continuously. The arm with the two mechanisms on either end of it, those mechanisms are clutches that will grip onto the wheel and they're controlled electrically. So now we have a device that can, by applying an electrical signal, the clutch grips the wheel, the wheel is turning, the arm is attached by a lever back to the dimmer. So we can use either an auto transformer or an ordinary resistance dimmer, and we can now control it with an electrical signal rather than a mechanical input.

This is huge from a control point of view and it led fairly early on to this, which you might think is a cinema organ, and you would be right. It is almost entirely a cinema organ, but it is actually a lighting control. It's called a Light Console, and it’s the invention of a man called Fred Bentham. It is in one sense a truly extraordinary moment in lighting control history and in another sense it's largely irrelevant - let me explain.

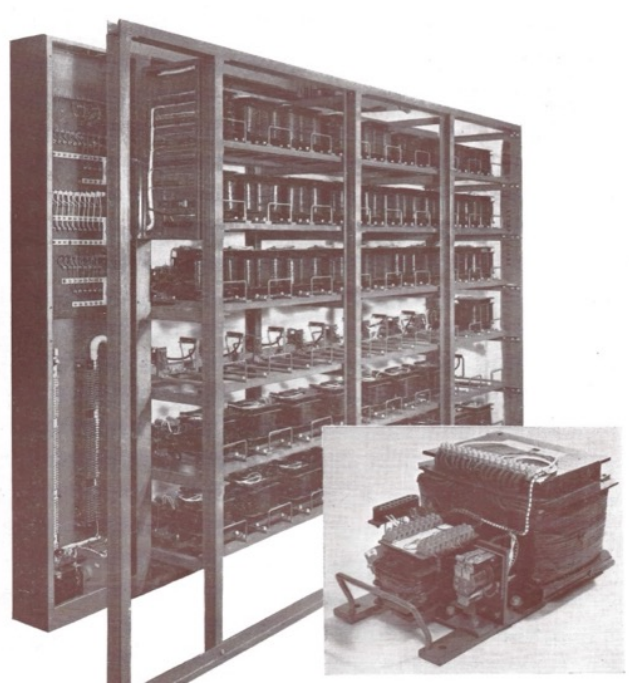
Fred Bentham had this idea that the existing lighting controls, we're talking about the mid 1930s, were terribly backward and didn't do what he was interested in doing. His great passion was something called colour music, which was performing light to record his music, gramophone records of music and he would perform light to go with the music. So he wanted something that was essentially an instrument.

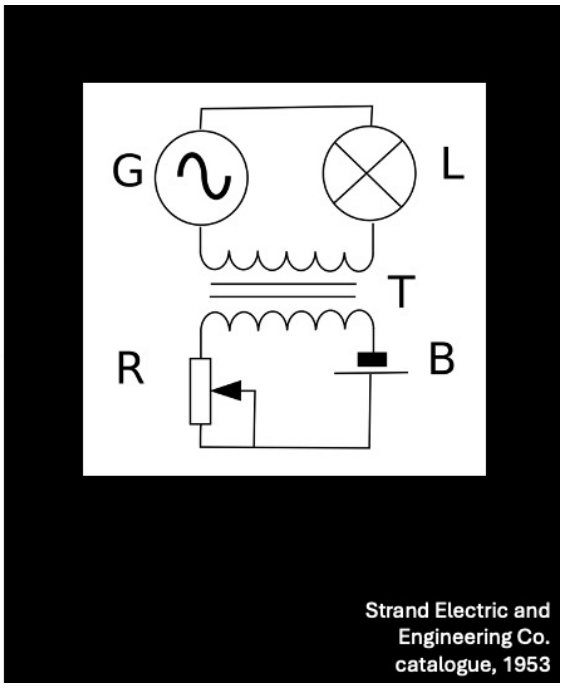
Bentham's insight was that you could take a cinema organ – remember cinema in the 1930s was a huge boom industry, loads of technical development and money going into that - you could take a cinema organ front end, you could take the Mansell clutch as a back end, that's the actual work of doing the dimming, and you could connect the two electrically – no electronics at this point, at least not anything that would do this – with a thing called the crossbar relay. That was a bit of technology that was developed for telephone exchanges, another growth industry in the 1930s. That was his stroke of inspiration.

And he created this thing. He was working for Strand Lighting, the leading stage lighting manufacturing company in the UK. And he somehow as a relatively junior employee persuaded the management that they should spend the money to build one of these. The first one in 1935 is a slightly smaller system than this. They didn't sell one for five years because everybody looked at it and go it's very interesting - it's totally weird, Fred.

They sold the first one in 1940, and kept making them until the mid 50s – sold 16 I think altogether. A commercial flop. Why is it a flop? Because everybody wants to control light in a different way. It was successful in particular niche areas. It was great for revue shows where you want to change light very rapidly, not necessarily particularly subtly - so that kind of performance of light to go with quite an active, dynamic performance with music.

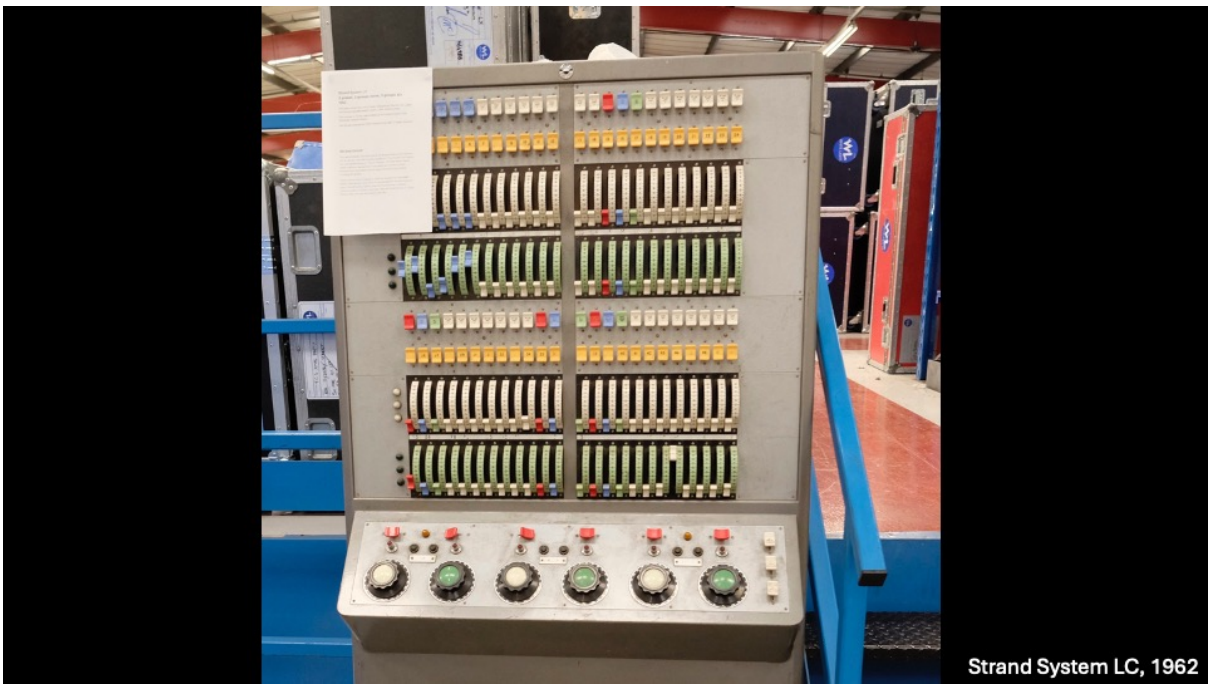
It was dreadful for drama – completely hopeless because you couldn't predetermine the levels that any dimmer would arrive at at the end of a cue. It relied on the operator keeping their fingers on the keys until the lights arrived at the level you wanted them to arrive at and then letting go. So it's quite imprecise and drama is increasingly wanting greater subtlety and precision in the lighting. Hold that thought.





We come to our next and final, for the moment, form of dimmer, the saturable reactor. This again is a rather ingenious device. We again put a coil into the circuit, the primary coil between the power source and the lamp. And then we have a DC control signal that goes through a winding in the centre of the core around the magnet. The DC control signal saturates the magnetic field in the winding and reduces the inductance of the coil and therefore allows more of the current to pass through. So again, we have a transformer-like object that can be controlled electrically. And at this point we've arrived at solid-state dimming – there are no moving parts.

It's fantastic. It's very expensive. So although it has advantages, not necessarily everybody's prepared to pay for it, but it does lead us to the possibility of something like this, which is, I've jumped ahead a bit here to 1962, but there are earlier precedents.

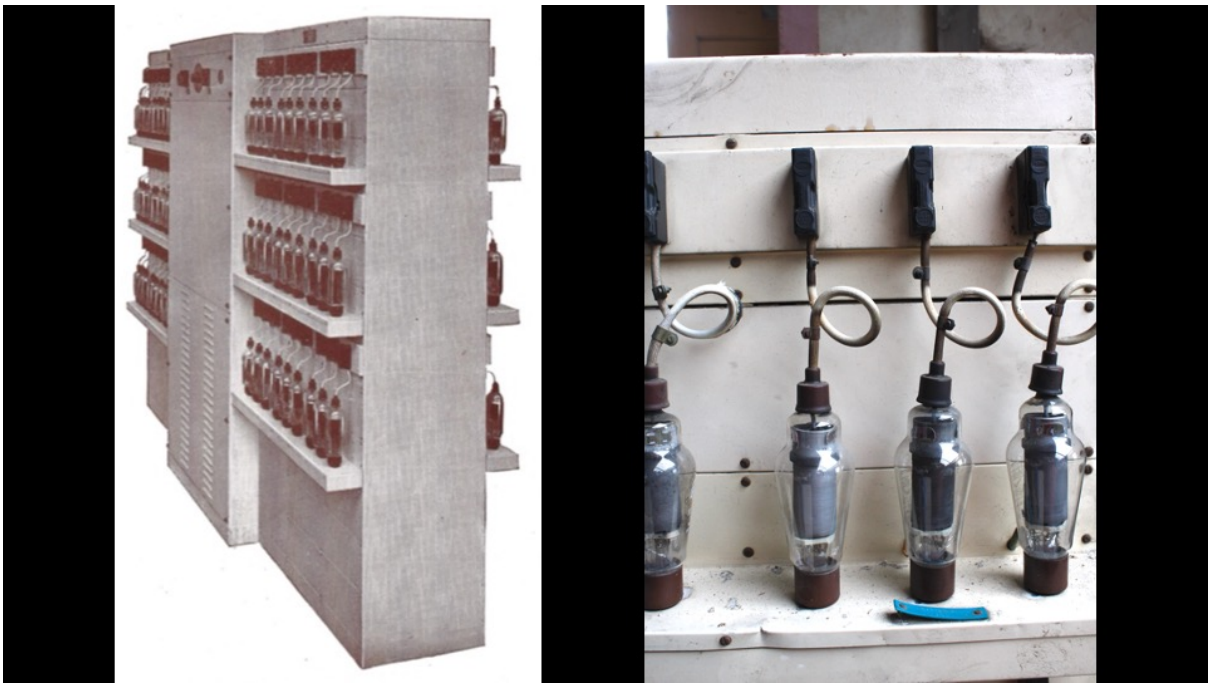


This is a preset lighting desk. And what that means, you can see there's a whole row of little faders. There are two faders for every dimmer. There's a white one and a green one. And which fader is active is determined by the master controls, which are the dials at the bottom. So what I can now do is I can set up the first cue of the show, say on the white faders with the master turned down to off. I can fade it up on the master and my lighting state arrives fully formed, very precisely set by all the levels of the different faders, onto the stage.

While that's live, I set up my next cue on the green fader, which currently master is down, is off, and I can cross fade again between the two faders. And I proceed through the show; each time my lighting state arrives fully formed as it were, onto the stage.

That's presetting, and this is what people lighting drama wanted. They wanted the precision of this and the repeatability of this system.

So that brings us to the age of electronics. Probably worth saying here, I'm going through the story at this point primarily from a UK perspective. Things are a bit different in continental Europe and a bit different in the United States, and particularly in this part of it the Americans get here before us. But I'll stick with the British story for the moment.



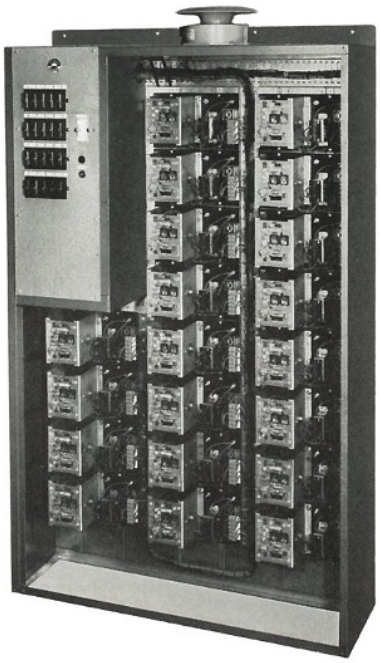
The thyratron is a vacuum tube device, as you see in this picture, which will do waveform chopping. I think the engineers in the audience will probably know what that is, but some people might not know what it is. I'm not going to try and explain it at this point, but essentially it's a much more efficient way of dimming by controlling the waveform of the AC current that goes through to the lamp than just

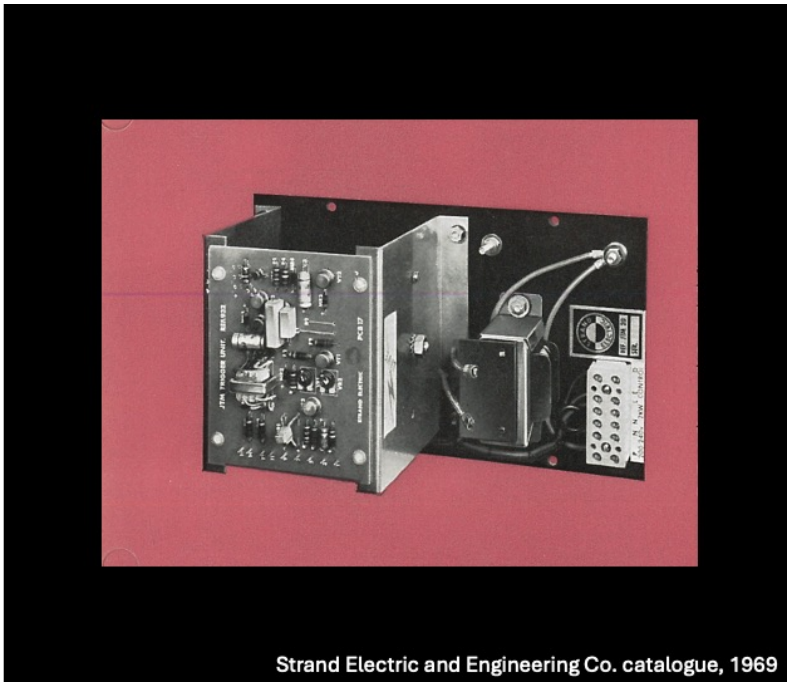
sticking a resistance in, which produces a lot of waste energy as heat. The thyratron allows you to do that. So electronics at this point have now arrived in our story.

Strand Electric and Engineering Co. catalogue, 1953

In 1950 – this is first introduced in the UK by Strand Lighting – we have one of these and it looks very much like, it's roughly 10 years earlier, than the one we looked at just now. Again, it's a 2 preset lighting desk. So we have the new dimming technologies, we have the preset lighting control. Theatre at this point is really is kind of set. You know, people have really started to get the tools that they want.

The thyratron is somewhat unreliable. there are all sorts of niggles in engineering a system that works reliably. Strand catch quite a big cold with it because they make quite a fundamental engineering mistake. That's a whole other story. Happily, the day is saved fairly soon by the introduction of the thyristor, which is the solid-state equivalent of the thyratron.





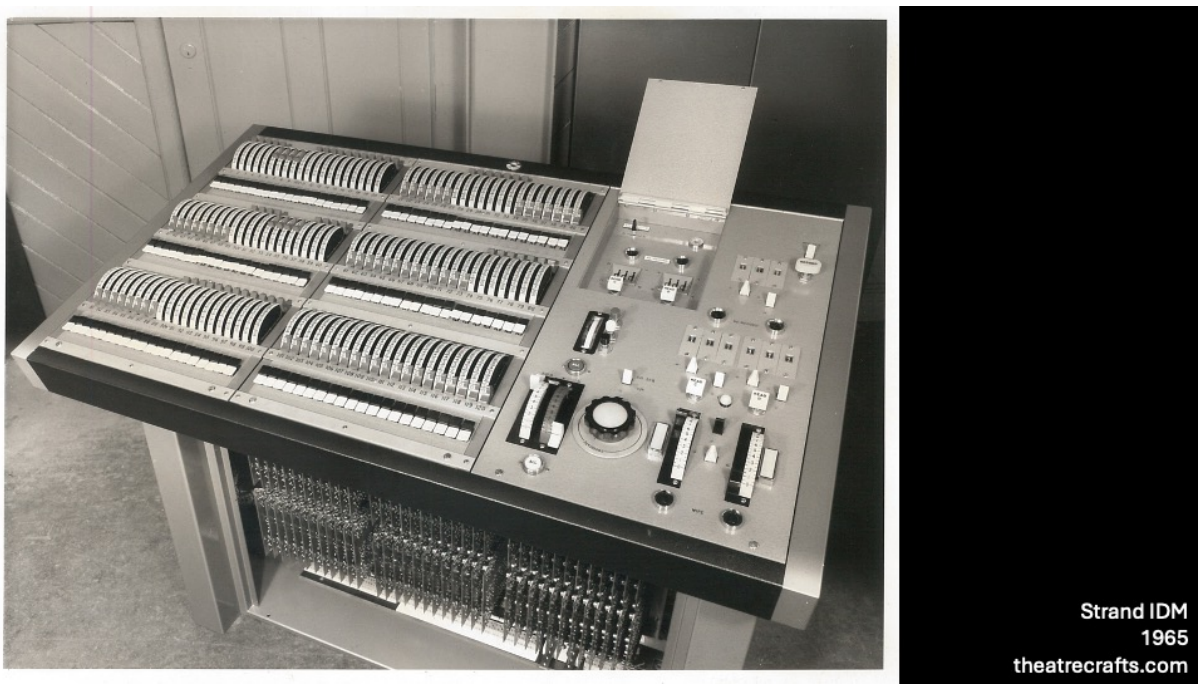
This is a thyristor dimmer from the late 1960s. There is some further development of this type of dimming, but for your standard filament-lamped lighting instrument, dimming is essentially a solved problem at this point. We have something that's reliable: it sits in a box, you stick it in the basement of the theatre or a little room somewhere out of the way, it needs almost no maintenance. It just sits there and does what you want it to do – fantastic.

Control, on the other hand, is not yet quite a solve problem because ambitions for what light does on stage are growing. People want more complex lighting, they want more lights and they want to do more things with them. And that means we start to hit the limitations of preset lighting controls.

Presetting is great if you don't have too many dimmers. If you've got 40 dimmers, 60 dimmers, an experienced operator can probably set up the levels on that number of dimmers in certainly less than a minute, maybe as little as half a minute. So you can get through your cues fairly quickly.

With a busy musical where you want lots of cues - you might want 10 cues in the space of 30 seconds – that's not going to happen with a preset desk. You can add presets so you can pre plan it further ahead. Fine, but how many? 3, 4, 5, 8? You've now got an enormous control room full of little faders, and you've probably got several people running around setting all of these levels.

What if we could have a memory system? What if we could record those levels into some kind of electronic memory, and we could call it instant dimmer memory?



Perhaps IDM, as Strand did.

IDM is not the very first. Strand's first memory system was KTV, fondly known as Klonk, in 1959, which used punch cards for memory. IDM is a bit more sophisticated if you use punched tape, and it presents us with a really interesting control problem that goes on to be fundamental to the way that we design the lighting control interface up until today, because we start to separate the state of the dimmers from the state of the control interface.

Let's imagine plotting a show on IDM. We've got one set of faders – it's one preset, as it were. We set all of our levels on the little faders. We like the state that we've got. We say, please plot that into a memory. We plot it into the memory. When we come to the performance, we play it back from the memory. Now what the dimmers are doing is driven by the memory, not by the state of the little faders.

That's fine until we say I want to override what the memory is doing. I want to make an adjustment. So now I just press the little button that says can you please control this dimmer with the fader, not with the memory. If the fader's at 0 and the dimmer's at 70%, suddenly the dimmer just goes out because it's now taking its level from the fader. You know, we've got this mismatch between the physical state of the hardware on the front end of the lighting desk and what the dimming's doing.

So then you have to have some kind of level matching system, some way of the operator knowing that the dim is at 70 and moving the little fader to 70 before they press the button. And it all just gets really faffy. And this is the thing that lighting control manufacturers are wrestling with for a while.

Rank Strand Lightboard, 1975

And it leads us to this, which is Light Board, in 1975. First built for the National Theatre just across the water from here, and a few sold in into mostly very well-funded German opera houses. Light Board brought with it several innovations, both in terms of the interface and in terms of the technology.

It was at least partly driven by a computer, a mini computer from DEC, the PDP 11, which I vaguely remember. We had one when I was at university all those years ago.

It has a keypad for channel selection, I think, not the very first, but pretty early to do that. There is no fader per channel, none of that. All that's gone. It has instead a what's called a positionless wheel or an encoder wheel, so little black wheels on the surface there – they turn continuously. So they have no absolute position.

You select a channel and the channel wheel – all it's doing is telling the desk to increase the level or decrease the level. It doesn't care what level it's at now – I don't need to know, just move it.

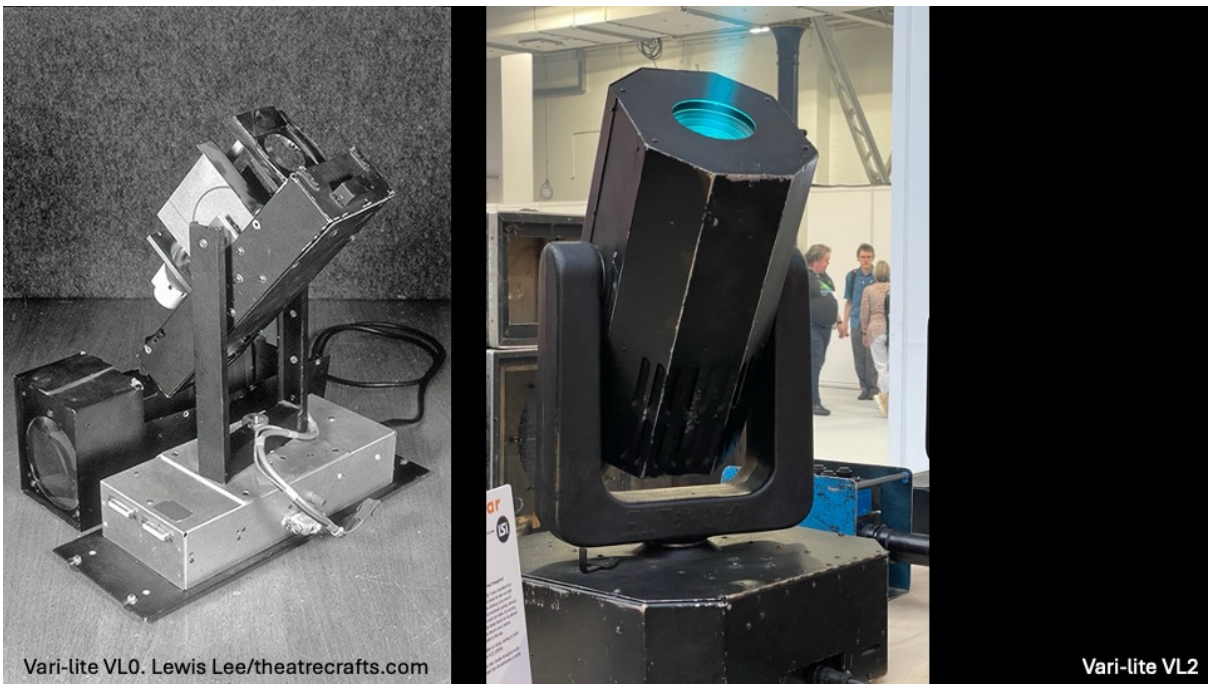
VDUs – screens for display – I think a first for lighting control in the Light Board, and it also had integrated some control of moving lights. So lights that are motorised so you can pan them around, so not just controlling the intensity anymore, and colour changers.

Light Board was not commercially widespread but enormously important as a milestone in development.

The thing that was enormously successful which spun out of Light Board was this: Galaxy. And I have to acknowledge two colleagues sat in the room who were part of the Galaxy development team and indeed responsible for selling them and installing them in the theatre. So you might want to have a chat with them afterwards – they know more about it than I do by a very long way.

So in 1980, the first Galaxy systems, very much based, as you can kind of tell, in the Light Board philosophy. And I would say thinking about the control of intensities of light, this is, and again, from the UK perspective, this is the high watermark. And it's interesting that the TV people who adopted these very widely kept them going for many years after they were essentially obsolete or obsolescent technology because there was no other control being made by manufacturers that did quite the things they wanted to be able to do, that the Galaxy could do.

And our story now really, in terms of this control end, is one of replacing hardware – Galaxy is a mixture of hardware, firmware and software – with a modern lighting desk, which is essentially a PC computer and a fancy box, lots of buttons on it, but essentially the thing is running in software.



But something else happens first. So in 1980 is the first Galaxy, also in 1980 the arrival of automated lighting. It's been around for a while – you've been able to buy lights with motors on for various things – but something really big kicks off in 1980 in America. A company called ShowCo, which was a sound and lighting supplier for rock concerts, felt they needed a new innovation. They wanted a light that could change colour automatically. As they were developing this, they were thinking about designing it, thinking about prototypes, a member of the team said, you know what, put two more motors on it and it moves. Pan and tilt so you can turn it and tip it. And so that's what they did.

They demonstrated a prototype to the rock band Genesis, and Genesis said, oh, that's that looks quite cool. Have $1,000,000 to develop it. This is the end of the 70s, when there was an enormous amount of money sloshing around in the music industry. Initially, the Vari-Lite system had a proprietary protocol for the lighting desk. They had to build their own lighting desk because no lighting desk could operate them. And it actually put the cue data – the instructions to each light for what it did in each cue of the show – in the light, not in the console. An early example of what we might now call distributed intelligence.

The Vari-Lite takes off. Lots of other manufacturers start making automated lights that are similar. There are patent wars. That's a whole story of its own, but essentially, from a control point of view, automated lights present a massive challenge because they work in a fundamentally different way to just controlling intensity. Intense is absolute. 50% is 50%. But a pan, the horizontal movement of a light of say, a setting of 180°. Well, which way did you rig the light in the first place?

Because if you rigged one light on the stage thinking it's facing that way, and another light the other side of the stage doing the opposite, well, which way do they turn? Do you want them to turn both the same way or do you want to both turn clockwise when you look from above?

Suddenly everything becomes rather relative and also these moving lights start having a lot of parameters to control. It's got pan and tilt, it's got intensity, it's probably got colour, which might be RGB, red, green, blue mixing or CMY mixing. It's probably got some sort of beam size control. It might have a softness with the beam control. It might have gobos that make little patterns within the beam.

These number of parameters are really growing and that's a management problem. How do we produce a desk that can somehow manage this system?

GrandMA 2 Stephencraft/wikimedia

So where we've got to – I'm not quite bang up to date with this – this is a Grand MA2, and we are now on Grand MA3, but it looks pretty similar. It doesn't look that different to Galaxy in that it's faders and buttons and instead of the old encoder wheels, it's got little flat encoder wheels, but essentially it's the same – you twiddle a thing and it changes the value – and screens, so the interface really hasn't moved on.

What's going on behind the interface is enormously more complex, but it does mean that a big part of the human end of lighting control is a kind of data management, because we've got this vast amount of data, maybe hundreds of cues, thousands of parameters being controlled, that somehow we have to wrangle into producing the lighting effect that we want on stage.

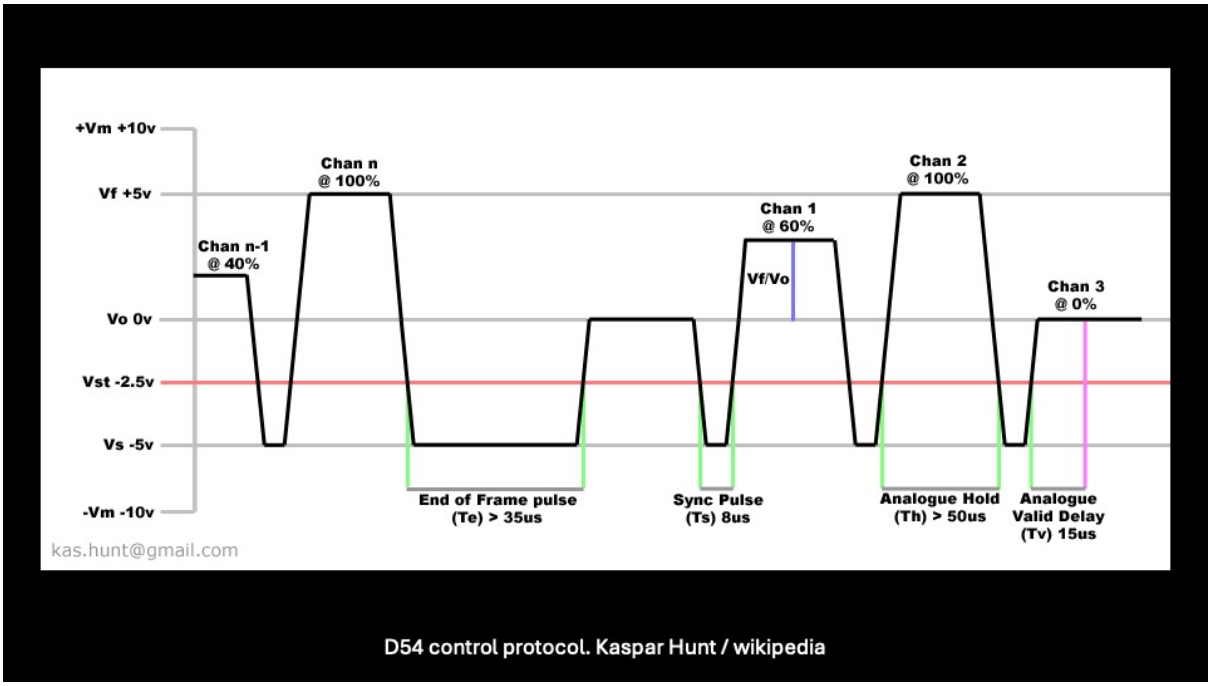
I have skipped over slightly – I need to go back to a question of great importance. We've got a lighting desk that we've talked about, dimmers we've talked about, there's a bit in between. How does the lighting desk talk to the dimmers?

Well, to begin with, once we get to the electrical stage, you just send a little low voltage and low current signal between desk and dimmer. So you need 2 wires. You want to add another dimmer, you add one wire, as there's always a common 0 Volt reference voltage.

So if I've got 60 dimmers in my dimmer room in the back of the theatre somewhere and my lighting desks at the back of the auditorium, I run a multi core cable with 61 wires in. It's fine.

What if you want 200 dimmers? What if you want 400 dimmers? 600 dimmers in big theatres. That's a very big multi core cable. What if you want to take your system on tour? That's an extremely unwieldy piece of kit. Wouldn't it be great if we only had to have one bit of wire going between these two things, or just a pair of wires?

So yes, we can do a thing called multiplexing, and that's what this diagram shows. This shows a multiplexing protocol.



D54 control protocol. Kaspar Hunt / wikipedia

So essentially we just send little pulses and each pulse, the voltage at the peak of that pulse represents how bright we want the dimmer to be. And there's a bit of clever electronics at the other end that decodes this and tells the dimmers what to do. And it's really extraordinary. 192 channels, initially around 1975, up to 384 channels with the D54 protocol, sent down a bit of something that is essentially a bit of microphone cable – it's not quite, but it's there or thereabouts. There's a few fiddles with it, there's a bit of calibration and occasional adjustment you have to do, but it worked pretty well.

And then people start to think, well actually, wouldn't it be better if this was digital? Because hey, everything's better when it's digital, isn't it? Because it's digital. So again, manufacturers start introducing their own digital protocols. More patent wars, more arguments saying the industry ought to standardise because it's bad for end users to have all of these different standards that aren't compatible with each other. And if they're going to standardise, obviously they should standardise on *my* protocol because it's the best.

Eventually the United States Institute for Theatre Technology gets fed up with all this and introduces its own protocol, and that's called DMX: Digital Multiplex, in 1985. And they were really thinking about dimmers, despite the fact Vari-Lites have been around for five years. So they're thinking 512 channels.

It's based on a standard called RS485, which I'm sure some of the engineers in the room will be familiar with. You know, very standard, widely available, well understood. You buy the parts quite cheaply, the electronic chips and things to make it work. That's great.

We send 512 channels of data between the two. That's a lot of dimmers, that's a lot of lights, by the standards of the mid 80s, but it doesn't go very far with automated lights. Once you've got an automated light that, say, has 20 parameters, maybe even 30 parameters that need controlling, your 512 channels get used up pretty quickly.

And also sometimes the moving lights say actually I need 2 channels because I need to do 16 bit. DMX is 8 bit. I need more precision than that, so I'm going to use two channels. So the numbers just go up and up. And that leads us to, first of all, DMX originally is a one way of communication. The lighting desk just tells the dimmers or the light on the end of it what to do. It has no idea whether it's done it or not.

Remote device management, RDM, comes in 2006 and that allows us to get data back from the other end. So your dimmer rack can report 'I've got no load'. If you thought there was a load, then

somebody's either unplugged something or the lamp's blown or the circuit breaker has tripped, so you might want to look at that.

With the problem of the total amount of data, people just start adding what are called universes. So you just say, well I'll send another DMX signal, so one part does one bit of the lighting rig, another part does the next chunk of the lighting rig and so on.

And then people work out, wouldn't it be great if we could send DMX data over Ethernet? Because the IT people have put a lot of development time into sending large volumes of data over networks extremely reliably. So various protocols are developed to send DMX data over Ethernet, and that's great. And then of course people start saying, well, if I can send it over a Ethernet wire, why can't I send it over Wi-Fi? Which gets us almost to the end of the talk.

And that's fantastic too, because for theatre applications, maybe there's a revolve on stage and you want some lights on the revolve and you want some dimmers. Getting power to it with slip rings is straightforward. Getting data via slip rings is not terribly easy to do. With Wi-Fi – brilliant.

If you're lighting the fireworks on the Thames at New Year's and you've got some lights on the barge, or your control position is one side of the river and your lights are the other side of the river, then clearly running a bit of electrical string across the river is not great. And sending a nice little Wi-Fi sort of signal, at least a wireless signal across the river is the way to go.

But it does mean that lighting control in some senses has become a highly specialised branch of IT. And certainly a lot of lighting technicians need to understand IP addresses and subnet masks and other interesting things like that.

Mirabella/wikimedia

I've really got us up to the early 21st century. I've not talked about the big next chapter, which could be easily be a talk on its own, which is the convergence of lighting and video – that will have to wait for another day.

Two things about the emerging future that I want to talk about very briefly. One of which is that everything that you can do in the real world, of course you can do and might want to do and might need to work out how to do, in the virtual environment.

So in virtual reality or XR, people are doing some really interesting work in how do we control light and particularly actually rather interestingly saying, can I control both the lights but also maybe other things in my virtual reality environment using a physical lighting desk? Because a lighting desk is designed to run live performances.

So everyone would do a live performance in virtual reality. Why would I not still control it with the highly refined piece of kit that does that?

And the other thing of course, that everybody's talking about at the moment is artificial intelligence.

This picture, incidentally, is Microsoft Designer's, which is an AI kind of image generator. I gave it the prompt 'The Future of Stage Lighting Control'. And that's one of the images it came up with.

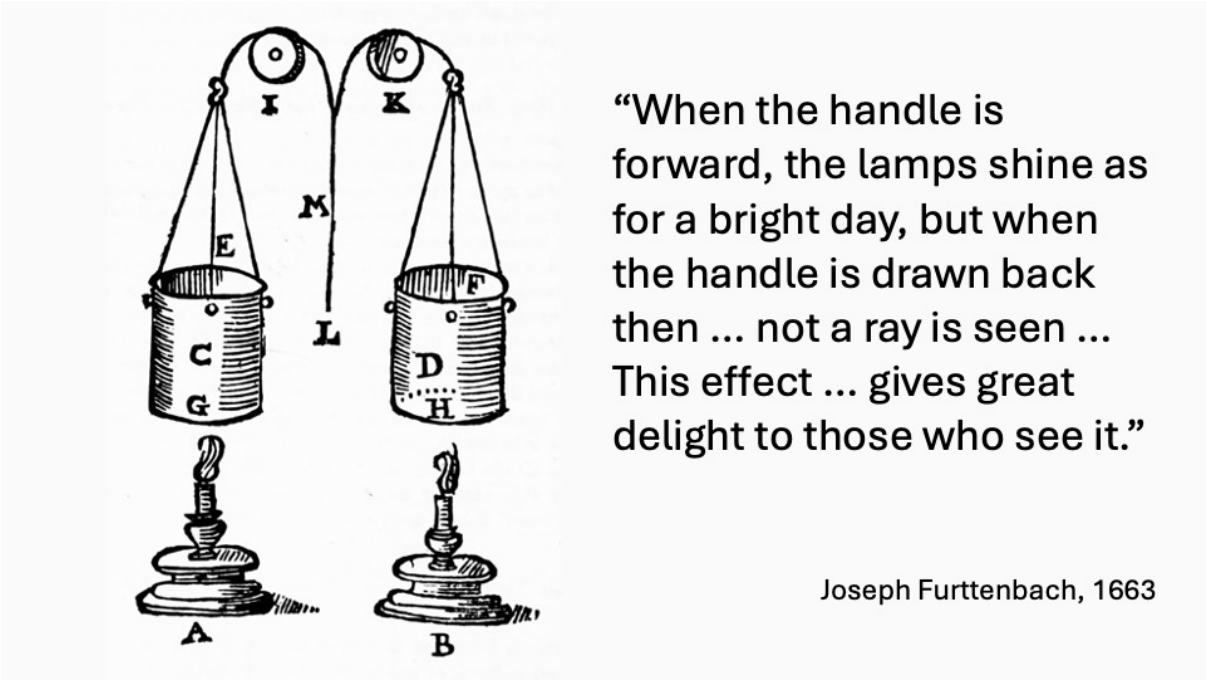
I'm delighted to discover that AI thinks that human beings are still going to be involved – you might still have a job, guys, that AI might productively help us with. And I know Rob Halliday is present in the room – some of these thoughts come from him (thanks, Rob).

I talked just now about the complexity, and we could do a deep dive into just why lighting control has become as complex as it has. But it's largely to do with this vast amount of data that we can potentially control, the huge number of light sources that we potentially can have and the parameters that they have. And it seems to me that we are still controlling *lights* rather than *light*.

We're still going, 'oh, I want those lights over there to be in a kind of reddy orange colour coming from that side of the stage', rather than saying 'can I please have a sunset from stage left'. And it may be that AI will get us to that point where it starts to suggest it's going to put lighting programmers out of a job. And of course, we might put lighting designers out of a job because the director can say that just as well as a lighting designer can.

Of course there is a quality to sunsets – you know, what kind of sunset do you want? If you can't articulate that, the AI can't give it to you. But the AI might just say, well, I saw a really nice sunset in a show that Paule Constable lit, and you like Paule Constable's work, so do you want one of hers or would you like more of a Mark Henderson kind of sunset?

So yeah, an interesting potential future. No consoles currently do it, but at least one patent has been granted in this area, so watch this space.



By way of closing, I want to return to this and to Furttenbach saying when the handle is forward, the lamps shine ‘as for a bright day. When the handle is drawn back, then not a ray is seen. This effect gives great delight to those who see it’. And ever since, that's all we've really been trying to do – to pull a handle and create delight.

Questions and answers

Question from audience member 1

One of the most complex lighting and effect shows that I watch from time to time is Strictly. Could you comment on how all that is managed and includes some computer generated stuff that's mixed in with the camera tracking and so on? How is that all managed?

Nick Hunt

Yes, I don't know that much about Strictly itself. I'm going to take a little bit of a punt and think it's probably a lot of it will be managed in a similar way to the Eurovision Song Contest, which I do know a bit about, just because I'm about to publish an article about it, and I've been interviewing some of the people involved.

And that's part of the integration and the convergence that I very briefly mentioned as what I wasn't talking about today, in fact. So certainly with Eurovision, there is a time code, which is essentially an

electronic signal that – because it comes from the film world – it says the time is now 2 minutes, 38 seconds and 16 frames. So depending on what your frame rate is, it gets down to that many fractions of a second. That timecode is attached to the music. The music in Eurovision is prerecorded apart from the live vocals of the lead singer.

The timecode drives the camera cutting, so the switching between cameras, it drives the lighting cues, It drives – with a certain amount of safety interlocking – pyrotechnics, stage automation, so anything motorised on stage. So when you watch a Eurovision performance, it's live in the sense that it's happening in real time – you watch the broadcast, it's happening right now on the stage in wherever part of Europe it is.

But it's not live in the sense that almost everything is predetermined. The only people who are really doing anything live are the performers themselves on stage – and even then, if they're playing an instrument on stage, they're miming the instrument – and the camera operators. And the people who are physically moving bits of scenery and what have you, obviously, but mainly in between the acts.

I'm going to guess that Strictly is in many ways similar. They're working to a much more rapid production schedule than Eurovision, which is in venue for around six weeks. It's not rehearsing for six weeks, but it's in venue for about 6 weeks. Does that help answer the question?

David Bertenshaw (audience member)

I can just offer a small comment if I may. Just talking to the staff a few weeks ago. Basically even though it is live music on Strictly – there's a live conductor – he is conducting to a timecode.

Nick Hunt

Yes. So a click track – the musicians get a click track which keeps him in time.

David Bertenshaw (audience member)

He is not setting the pace, the click track is setting his pace. So the live music follows the click track and then the effects follow that.

Nick Hunt

Yes. So a lot of these things are less live than they might appear. So it's interesting, if you look back to the early series of Strictly, visually, the visual aesthetic was very much a studio light entertainment aesthetic. And now it's very much not, well, not completely, but has moved a lot towards a kind of live event aesthetic. So the conceit is, you the viewer are sat on your sofa at home or watching on your phone on the bus or wherever you're watching it, are transported into a venue where a live event is taking place. This is no longer a television studio, even though it actually is. It's a yeah, It's a live event with a real audience. And it's lit like a quite a lot like a concert. Not completely like a concert, but quite a lot like a concert.

So there's the creative shifts and the technical shifts which go hand in hand from that point of view. But you can't do that complexity of lighting and operate it completely live. It's not going to happen or it just goes wrong too much.

Question from audience member 2

Hi, my background, I came up through rave lighting. I started work at the Astoria and so on. And my career just predates DMX. So I was starting on very flashing manual dimmer desks, but that was often running spinning disco lights rather than conventional theatre fixtures.

I still do a lot of live busking working on rigs 4 to 20 universes. And certainly for things like Strictly, yes, that tends to be much more pre-programmed on the day. Whereas what I do is I'll have a lighting desk that's built out of lots of building blocks that are effectively pallets and presets and things that I can then add together, but I then choose them live on the night.

And if I do the same show three nights running, I might do a completely different show for a given song because today I'm going to go red, orange and green and slow movement and so on.

So again, I'm very interested in Bentham's ideas because what I do for rave lighting can be incredibly complex content, which has to be extensively pre-programmed into the building blocks, but I'm still actually playing it live using the playback parameters of what I've programmed rather than the actual parameters of the fixtures themselves.

Nick Hunt

That's a really good point, I think. And to be clear, mostly I've been tracking the history of theatre, although it's impossible to because the theatre world increasingly is influenced by and influences other types of performance. And I think you're right – if you look at the control desks that are made for live music, live events, the interface is done quite differently because they expect you to operate them quite differently in exactly the way you've described.

And I would say – it's a bit of an oversimplification, but broadly speaking – concerts fall into two categories, one of which is highly pre-programmed in the way that we just talked about with Strictly and Eurovision and things. So like a Kylie Minogue concert: click track, time coded, Kylie will hit a mark on a beat in the music in order to be in the right place for a light to turn on or a piece of video to do a thing.

Whereas other concerts will be much more a lighting director, a lighting designer will be going: yeah, it's rehearsed. I know what this song's about and I know maybe the colours I'm going to use and the effects I'm going to use, but it will be a bit different every time because it's performed by somebody who has an artistic sensitivity to how an audience is responding and to how the musicians are playing.

Audience member 2

And that may change from one audience to another audience. Yeah, 'cause if I've got a very sombre crowd who are sitting enjoying the elegance of the music, I won't be flashing my strobes. Whereas if they're up for it and they're dancing on the same song on the following night...

Audience member 3

A question on user interfaces. Back in the days with the more mechanical systems, the grouping of lights together is, you know, pretty tied up, you know, broomstick style. You're only going to do so many together. With today's systems of very large numbers of lighting units, potentially there's an opportunity of how you might group them together. I can see in a theatre, typically those groups might be relatively static, but there may be other instances in these more live performances where they're quite dynamic and you might want to change the groupings as you go.

Are there any advances in the visual user interface of how the groupings are set up? Because going back a bit, you'd have tables or some rather simplistic way of doing that. But are there user interface techniques and, sort of built in your modelling of the lighting that you can configure.

Nick Hunt

I'm going to ask Rob Halliday to answer that question, because Rob is probably the biggest expert in the room on this one.

Rob Halliday

The interesting answer in many ways is actually we've gone backwards, because what was interesting about the Galaxy console that you saw there in the light board is that that was all designed around grouping, and those wheels were designed to let you effectively mix lighting live on stage.

The main pullback that's happened now is all the modern controls only have one interface, one wheel. So you can select a group and you can adjust it, and you can select another group and you can adjust it, but it's very hard to select two or three groups and adjust and balance them. And it's really interesting that that retrograde step has happened.

For the most part, no, what you're describing, where you set up a whole bunch of groups and you then realize you need some more, and then you realize you need some more. And then the problem becomes the management of: 'which group was it?' And there desperately needs to be that. Not just because there are more lights, but because if you imagine you have lights that can move and change function, the grouping of those will change moment by moment during the show.

The few tools we have got are things that are effectively search tools where you can say select all the lights that are in red, select all the lights that are in this setup. But the short answer is it's an area that massively needs improvement.

I had my hand up earlier just to say on the Strictly question, Nick's being slightly modest because the interface to the lighting on Strictly is a human being. That human being at the moment is one of the ex Rose Bruford lighting programming students. You know, the machine helps him do his job, but that person is making all of those decisions. Because those people get so used to how they make their tools work and are so busy making the show very often, I think what they have a hard time doing is looking forward to how it could be better, which is how we end up, I think, a bit stuck. Sorry - we should be better.

Audience member 4

You haven't mentioned 3D holographic projection in your show. Do you think this is going to become standard in the future? They've got that ABBA show running, which is quite popular, and in the future, as it carries on, these would be cheap shows to run. So do you think there might be this kind of two tier model in the future where most entertainment is this kind of fake stuff? And then for VIPs, who've got loads of money, the real performer might actually turn up. And if he does, how do you know it's him?

Nick Hunt

Yeah, a couple of things to say. Firstly, 3D holography still doesn't really exist - the idea that something can appear in the middle of the room, and appear to be completely solid and can be viewed at from all angles, you know, in full lighting, we're not there. And ABBA Voyage doesn't do that. It relies on the fact we've got a limited range of views looking at a stage and some very cleverly thought through control of light and space.

And certainly when I saw it, as somebody who has spent a lot of time over the years looking at stages and working out what I'm looking at and how it's been achieved, there were points in that where I still

went, oh, hang on. Oh, maybe the screen's *there* on the stage? You know, which of the little sort of steps and bits and pieces…? And you go, oh, I thought that was the screen or I thought that was part of the video content – no, it's a physical thing. And it's incredibly clever from that point of view.

I don't think it's the cheap answer to anything. Not for a good long time. I mean, that show was mind bogglingly expensive to put together and only makes sense either as a really big punt that this is a format that in 10 years' time is going to be making a ton of money, or the sense that this is a show, not just a format, but an actual show that we can roll out to multiple venues, which of course, potentially you can.

I mean, it's not cheap to build even a temporary venue and put all of the technology in it. But the really expensive bit was all of the development work to get the technology to the point where it can do what it does. I think it's really interesting, but I don't think it'll ever be a sort of silver bullet answering anything.

And also, it's not a concert, it's its own kind of experience. And it will be both artistically better and I think commercially more successful if people recognise that it's a new form rather than, oh, it's a cheap way of doing live shows, because that is not the experience you have. You do not engage with the members of ABBA in the way that you would if they were physical human beings on the stage, right.

Audience member 5

Thank you for a terrific presentation. I was struck that there were points where something else clearly influenced this space and other points where it noticeably didn't. So the pipe organ and the theatre organ had a clear input. Did anybody ever make a lighting desk with flying faders though as another way of solving the disconnect between the dimmer and the desk?

Could you say something about just generally the interplay? What did theatre gain from somewhere else and give to somewhere else?

Nick Hunt

Well, to answer your specific question, yes, but not often. My possibly slightly prejudiced, and I'll say it upfront, slightly prejudiced view on this is that flying faders are everywhere on sound desks. For some reason people are prepared to spend a lot more money on sound desks than they are on lighting desks. It's entirely unclear to me why that's the case, but nevertheless it's seems to be true.

Therefore, it's relatively rare because it's an expensive piece of hardware to do it. So, generally speaking, lighting desk manufacturers have found other solutions to the problem.

[Inaudible intervention by David Bertenshaw, pointing out that flying faders are only useful for controlling single values, not groups of values at different levels, which is often needed with lighting desks.]

The big picture of your question is one that I had an argument with somebody at a conference about once. My claim is, which I might be slightly overstating, but I think it's broadly true, is that theatre never invented anything in terms of technology.

Theatre has never had any money and therefore it's been brilliant at hoovering up other people's technologies and repurposing them to its own ends where it's been enormously inventive and innovative. But in terms of what I'd think of as really a fundamental technology, no – it waits for somebody else to invent something.

You know, we talked about limelight, we talked about how limelight was invented to do surveying, map making. Carbon arc is invented because it's kind of an interesting bit of physics, and so on and so on and so on.

So that's my view. I mean, somebody might at some point work out that theatre has invented something really from scratch, but I rather suspect not.

Audience member 6

I would be interested in your view on how sound can control light, and what comes to mind is ELO and Jean Michel Jarre and the control of lasers.

Nick Hunt
Yeah, that's a strand through this story that in a in a one hour talk, I sadly can't get to, but it there's a really interesting story to be had there. Everything from fairly crude 'stick a microphone next to the sound desk and take that feed and get it to control the brightness of whatever you decide to control with it'.

And indeed, if you get some cheap and cheerful disco lights from your local shop that sells kit to DJs and things, they've got a microphone built in and you can switch it into – I'm DJ-ing, I'm too busy to do the lighting as well, but at least I can get the lights to flash and do something in time with the music.

So there's that level of something very, very simple. At the more sophisticated level, I would say more likely we're taking some kind of input from the sound side and saying, just give me that as a trigger. And I will work out exactly what I want to do with it in lighting terms and get it just to give some kind of trigger that's telling me what's the fundamental beat of the music. Or can you please give me a trigger when this event happens in the music?

In order to really tightly synchronize something, that gets us into the whole world of what's called show control, which is all of the different systems of performance, potentially cuing each other or interacting with each other or knowing what the system state of another bit of the system is in order to then respond to it.

[Inaudible comment from questioner]

I'm sure – I'm not familiar with the detail of that, but but it can go in any direction. It might be that we want – the pyrotechnics operator is the person who's going to push the button when the performers have moved safely away, but we want a lighting change to happen at the same moment the pyro goes off. Well, then the pyro system's now going to trigger the lighting desk, right?

Audience member 7

You showed us a picture of a very early concept of a gel scroller. And whilst I was working at Neg Earth not too many years ago, we did a whole load of gel scrollers to go into the Royal Albert Hall for Cirque du Soleil. Do you still think there is a place for gel and scrollers as a form of colour control within the theatre?

Nick Hunt

Well, the gel manufacturers haven't completely stopped making gel, I suppose is the observation. I'm assuming they're making less gel than they used to. Although slightly bizarrely, many years ago I visited the Lee factory in Andover, which is one of the main manufacturers of lighting gel. And they

told me that it's a weird thing that every time we introduce a new gel to the range, because every so often the gel manufacturers say, there's five new gels this year. And I think surely from a commercial point of view, this is madness because only you're increasing your production costs and your warehouse has got more stock in it, but surely nobody's buying more gel. They're just buying different gel. But they said, no, but the old gel still sells just as much as it ever did. And people also buy the new gel and where's it going?

But surely at some point gel manufacturing stops being a thing. Well, I mean film and TV will still want it because they still want to put a bit of colour correction over a window to colour correct some daylight and those kind of applications.

Audience member 8

In that picture behind you there must have been some consideration about security and stopping the rats eating the cables. As you move now to sort of Ethernet and particularly Wi-Fi, what consideration is been given to security – the idea of a malicious actor within an audience saying oh, I'm going to screw this up. It must be horrific.

Nick Hunt

It's an old problem. With Galaxy desk, which I've shown, Strand introduced the great innovation of an infrared remote for it, which is mainly used for when you're focusing the lights. You can stand on stage and you can turn the light on without having to have somebody sat by the lighting desk to do it for you. But it didn't have any security initially. So at least in theory, you could walk into somebody else's theatre with the infrared remote and if somebody hadn't turned it off on the desk, you could start pushing the button. So it's rather an old problem.

I would say that – Rob, where are we at with this? You are more up to date than I am, but I mean, apart from anything else, you are running completely independent networks. Generally, you're not running your DMX data over the general Ethernet network of the building.

Rob Halliday

The answer is nobody's worried about it, and they're starting to now. And the reason they're starting to now is because if you imagine your show control is also controlling the position of the performer on the trapeze flying system, you don't want somebody infiltrating that. So for example, the next task on the working group who look after sACN, which is our current network lighting control protocol, is to add security tokens to it so that you will have to log in and connect to it. That's not there, but it's basically the next thing on their list for the reasons you allude to. It's coming.

Nick Hunt

So presumably, then, when the show is late going up, the excuse now will be we've forgotten the password, right?

John Fuller (chair of the session)

We, we've got two things to do. First will be a vote thanks. And the second, I will make an announcement about future events and what we as organizers of these events try to achieve. And hopefully those of you from the stage background might be inspired to come to some of these other events. But first I'll pass it to Roger, who is co-organizer of the events, to make I hope some wonderful positive comments about the presentation.

Roger Ward

Nick, thank, thank you so much. I mean, the level of questioning we've had today, it's been a fascinating journey from the 17th century to today, and also looking into the future.

I think by the level of questioning we've had from the audience and also the size of the audience, there's been such energy here today, which has been great because none of these things happened without a lot of work. You know, there's myself, there's John. Big thanks to Kieran for this, for finding you. I don't know how we got all these new people to come in, but please come to our next lecture. But the but the but the main thing, I think is that you're all very welcome, but tell your friends about it.

But really the big thanks to the man himself. It would be nothing without you and it's a lovely end to the year. So big hand to that.