

Inventing the future: The National Theatre's Lightboard

Words: Rob Halliday

It's quite amusing to enter the PLASA Show, that showcase of the latest in high-tech entertainment lighting technology, wheeling a 40-year-old lighting console; a 40-year-old lighting console that's showing its age, wooden frame battered, monitors missing; a 40-year-old lighting console that doesn't actually work and, if we're honest, may never work again. And yet, despite all that, for it to be the thing that everyone stops to look at, to ask about, to want to touch.

The object of that attention – and, I suspect, the oldest exhibit at PLASA 2016 – was Lightboard, the lighting control created for the opening of London's National Theatre in 1976. The excuses for having it there, and organising a full-house talk about it, were the 40th anniversary of the opening of the National, the fact that the development team behind it and other milestone lighting-control products from Strand from the mid-1960s through to the early 1990s were nominated for this year's Gottelier Award, and that we'd recently recovered a Lightboard after years of being hidden away in, of all places, a water tower in West London.

The 'we' here is the Backstage Heritage Collection: the loosely formed organisation described in these pages before (*Set & Light*, issue 113, Winter 2014) with an aim of documenting and, where possible, preserving older lighting and other entertainment production technology. It began with an interest in the equipment, but what has become more fascinating is the stories of how the equipment came to be made, of the people who made the products and of the bigger social history that encompasses it all. We are lucky that for many of the products, the people behind them are still around. Give them a little nudge and fantastic stories fall out – which was the case with Lightboard; there was plenty to talk about.

My fascination with it perhaps stems from its appearance on the cover of the

lighting textbook with which I grew up: Richard Pilbrow's *Stage Lighting*. Richard had parleyed his work as Olivier's lighting designer for the National Theatre Company into a position on the building committee that was formed to advise architect Denys Lasdun on the kind of performance spaces the proposed National Theatre building he was designing should contain. From that, Richard and his company, Theatre Projects Consultants, had been appointed as the technical consultants to the whole project.

Always inventive, always pioneering, never satisfied with existing technology and constantly striving to find better ways of doing things – descriptions that still apply as he continues to work despite supposedly retiring – Richard sensed a once-in-a-lifetime opportunity to advance the game, justified in part by the demands of the way that the National intended to work – three theatres each playing multiple shows in rep – and in part by the complications of the building, particularly the big Olivier Theatre. Every technical department would need clever systems to keep up.

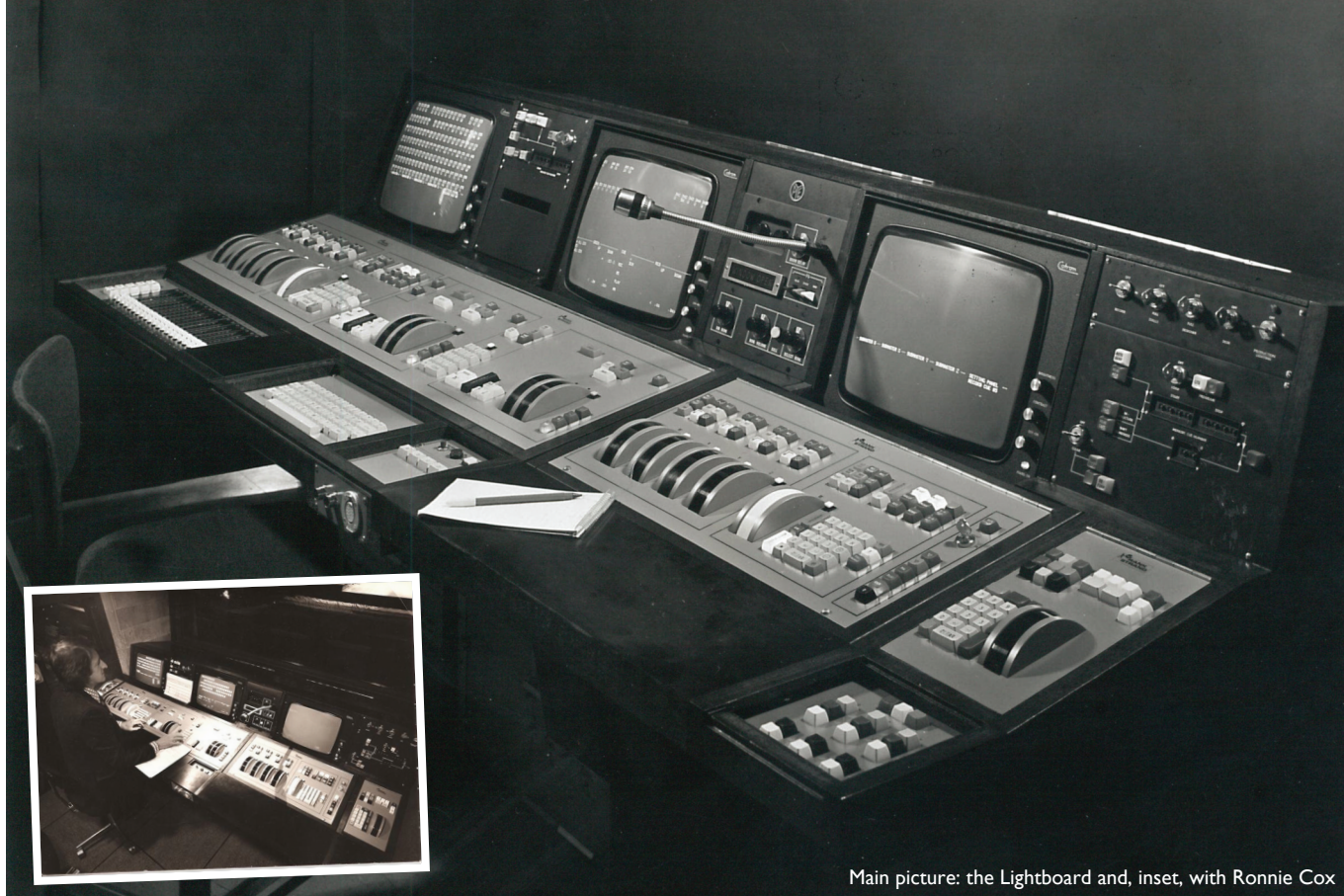
For lighting, Richard knew there wouldn't be time to completely change lighting rigs or even focus between shows, so he designed a saturation rig, with enough lights to allow a big permanent cover from all the useful directions, plus some lights that could be set specifically for each show in the rep, and a handful that could be refocused from show to show. Innovations here included the use of CCT's Silhouette zoom profile spot, first developed for the BBC but now adapted to theatre with a unique 'rep shutter' assembly, where shutters could be set and locked and the shutter cartridge then lifted out of the light and replaced with one for another show. For the Olivier, where the overhead rig was always likely to sit at a height unreachable by tallescope (even in the less-fussy 1970s H&S

environment!), TV studio-style short hoists were installed, equipped with moving lights – Pani automated yokes fitted with Strand 243 Fresnels. The key point was that there was to be no time wasted re-patching between shows: every light would have a dimmer, meaning over 400 dimmers in the pro-arch Lyttelton, over 600 in the Olivier.

The time all of this was first being specified, the late 1960s, marked a fascinating point in the evolution of lighting control. Directly-driven dimmers had been replaced by mechanical clutch-driven dimmers, these by electronic valve thyristors, then these by the solid-state thyristor. The control end had gone from the mechanical Grandmaster to Fred Bentham's remarkable Light Console Organ, through to systems that actually allowed precise dimmer levels to be preset, or even gave designers a stalls control they could operate while sitting with the rest of the creative team, as at Glyndebourne and the National's first home, the Old Vic.

Then the memory revolution: lighting controls that could remember and recall states rather than having to stop and plot with paper and pencil. Theatre wanted this, but the bigger chequebook of television – the new independent companies, the arrival of colour TV – drove it. Strand had early systems like IDM (Instant Dimmer Memory) but the real revolution came not from an incumbent (as the iPhone shows us, it rarely does; established companies fear dramatic change) but from an outsider prepared to take a completely fresh view. In memory lighting control, the revolutionary was Tony Isaacs, working for Thorn. His creation was the Q-File, which many acknowledge as the first memory control to work properly.

Q-File's revolution wasn't just memory: it was also solving the problem of how to control lights in a memory system, where the traditional fader-per-dimmer was a problem because the



Main picture: the Lightboard and, inset, with Ronnie Cox

faders couldn't move as a cue was played back. But did you actually need a fader per dimmer? Isaacs' brilliance was to bring the control to you, rather than you reaching for it: type the number of the dimmer to control it. Now just one motorised fader would suffice: select the light, the fader jumped to the current level, adjust. The crossing of the ages is that this modern motorised fader sat next to a keypad arranged like an old-fashioned cash register or tabulating machine, columns of buttons for hundreds, tens and units.

Then one more revolution: computers. Though both IDM and Q-File were memory systems, neither were computers as we now think of them – rather they were job-specific 'memory lighting machines', powered by stacks of custom transistor-based logic. But the coming mini-computers could do this work, turned into lighting controls largely through software that could be adapted if users weren't quite satisfied with the way it worked. Strand made this move with DDM; in America, Gordon Pearlman took the same approach with LS8: the first computer to run the lighting of a show in Broadway, the original *A Chorus Line*. Both systems were based in mini-computers from Digital Equipment Corp. That a later Strand system, MMS, was not computer based and was again created using hard-wired logic suggests that the mini-computer approach, while versatile, was

expensive. But MMS did bring one last key element still with us today: the channel control level wheel – an infinite control allowing familiar control (its shape follows Strand's old quadrant faders), unaffected by cue playback but also able to cope with adjusting groups of lights at different levels.

The problem for the National Theatre was that none of these consoles were capable of controlling the sheer number of dimmers involved. Plus, Richard Pilbrow didn't just want a bigger version of any of them. As a lighting designer, he wanted a better tool for making lighting. His summary: he wanted a lighting control 'which offers to the artist far greater opportunities for the subtle manipulation of light than has been possible hitherto, that will in time extend the boundaries and possibilities of stage lighting'. At the same time, it had to deal with the practical demands of the National's rep schedule and rep rig, ideally offering integrated control of the moving lights, colour changers and slide changers that would be part of that rig.

Since there was nothing that would do what he wanted, he and his partner at Theatre Projects Consultants, Dick Brett, wrote a specification for something that would. It came to be called TCS: Total Control System.

Looking at the specification now, it's clearly the work of two minds: Richard's talk of the artistic demands of lighting balanced at every step by

formal, practical descriptions of how this might be achieved from Dick in a language one suspects learnt from his time in studio engineering at the BBC. The key points: 'heads-up' access for the operator using a calculator-style keyboard while keeping their eyes on the stage; VDUs giving information about the rig and cues; integrated control of moving lights, colour changers and the like using a 'data highway' around the theatre; and complex cue timing with up to six overlapping fades running to pre-defined times or under manual control.

Plus, at its heart, not just one channel control wheel but a series of extra wheels, 'group masters', to allow multiple lighting components to be mixed and balanced together under fingertip control, rather than the select-adjust-select-adjust routine on earlier (and, ironically, current) lighting consoles. When you later brought back a cue for editing, the wheels would remember the building blocks you'd used to make it in the first place, letting you make adjustments easily without having to figure out all over again how the state was made. The perfectly fitting name for this part of the console: the light palette, a tool for the lighting artist. But, of course, the console would be stuck in the control room while that artist would be sitting in the stalls, so, in addition, a second palette was specified to sit at the

production desk; if it was easier for the designer just to reach out and balance a state, and they wanted to, they could.

The specification was issued. Rank Strand, in part, one suspects, trying to reclaim the high ground stolen by Thorn, accepted it. And then their team of engineers started figuring out how to actually build it.

It was quite a team. Their leader, Chief Engineer Martin Moore, had worked backstage at college and later in the West End, running the consoles to replay Pilbrow's design for the musical *Blitz!*, among others, but had also spent time looking after the CDC6600 supercomputers secreted away on Polaris submarines. The people he hired were recent physics or engineering graduates and also lighting designers or console operators for amateur companies, sometimes moonlighting in the West End. They understood theatre, but had the engineering background to apply to solving the problems theatre presented. By the time of the National, that team included David Bertenshaw, Tony Brown, Rick Dines, Vic Gibbs, John Hall, Edwin Lockwood, Tony Payne and others.

Their first problem: how to make a console that could cope with the sheer scale of the National. A PDPI 1/05 had run the DDM console built for the Royal Shakespeare Company. The newer, more powerful PDPI 1/35 was looking like a good bet for TCS (the same computer would go on to run the entire British Air Traffic Control System for many years). However, calculations suggested even that wouldn't cope. For 1,000 channels, experiments suggested each channel needed to be refreshed in less than 30ms for fades to appear step-free; that was also a good timescale for scanning all of the buttons on the console so as to not miss any key-pushes. Around that, the computer would also have to update the twin displays and the backlights on the keys used to indicate key status, and deal with the stalls control and its display. Plus, there was the potential for those six overlapping fades with their own times. The 1/35 couldn't do the maths fast enough (just for comparison, it had a processor operating at about 1Mhz, and 64kb of memory; your iPhone has

2Gb of Ram and a 2.2GHz processor. And the iPhone costs about \$650; the PDPI 1 was about \$30,000 in 1973, so perhaps \$200,000 now).

Strand's solution: they designed their own co-processor just to handle the channel processing. A fast 16-bit hardware processor implemented in Schottky TTL logic, it was power hungry but fast – a heady 6MHz!

Software development meant more investment for Strand, replacing the paper-tape systems used for DDM with a fanfold paper-tape reader and then, ultimately, with a Plessey disk cartridge, and purchasing DEC's RT 11 operating system. But they didn't want to spend too much, so the development 1/35 was actually one of the two machines that would go to the National. The software was written in DEC assembler code for speed; eight man-years of coding, but the final software occupying just 90kb. By contrast, the operating system in your phone occupies about 1.3Gb.

The system was developed to the original schedule, in and working by late 1975 – albeit that delays to the building meant no shows would appear there until 1976. Strand marketing feared the Total Control System moniker was too over the top, so it was replaced by a simpler name: Lightboard, although TCS persisted on much of the console's documentation.

It wasn't without teething problems – what cutting-edge systems ever are? – and it is slightly ironic that one of the biggest enemies was the lighting rig itself, with harmonics from the thyristor dimmers, and the load-managing system installed with them, often causing the computer to crash until appropriate filtering was fitted.

Lightboard also presented an enormous learning curve for the National Theatre crew, moving to the new building from the company's first home, the Old Vic, and jumping straight to Lightboard from a multi-preset manual console. But they quickly came to embrace and then love their new controller, figuring out, as all good console operators do, not just how to work it but how to use it to achieve whatever crazy or outlandish requests a lighting designer or a show made. Their feedback was incorporated into ongoing

development of the consol, for the Royal Opera House and then as it evolved into Lightboard 2, which added colour displays and more group master wheels at the behest of the wealthy European opera houses. Eleven Lightboard systems were ultimately made and sold.

It was probably too expensive to spread much further than that, but technology marches ever onwards and the coming of the micro-processor gave Strand's ever-inventive engineers new tools with which to create lighting consoles – and at a lower cost. (They weren't the only ones taking advantage of this, of course; the same year the National opened, a tiny new company called ETC got their first console up and running, based around Intel's new 8080 microprocessor.) Lightboard's clear descendant is the Galaxy, beloved by theatre and television operators alike. The resemblance in the general layout and, in particular, in those group master wheels is obvious, but the hardware behind it was quite different. Motorola's 6809 processor provided a fast hardware multiply function, but the Galaxy complicated things by having faders – Highest Takes Precedence (HTP) control – as well as the group wheels, which were Latest Takes Precedence (LTP); HTP required more calculation. Each processor could deal with only 48 channels at a suitable rate. The solution: to add more channels, add more processors, up to a maximum of 16, so 768 channels. Supporting that was 16kb of memory for the biggest customers, 8kb for the more cash-strapped.

Ironically, when Lightboard reached the end of its life at the National, a decade after its debut, the Galaxy chosen to replace it couldn't match all of its functionality: it couldn't then control moving lights. The ever-resourceful NT crew just engineered their own software-based solution running on a PC!

At the NT, the Galaxy was later replaced by Strand 500-series consoles, and those in turn were replaced by ETC Eos; the theatres now run Eos Ti consoles, controlling numbers that make that original 1,000 channel spec seem puny – 2,000 dimmers plus 80-odd moving lights in the Olivier, 1,100 dimmers plus 90 moving lights and scrollers in the Lyttelton, plus often

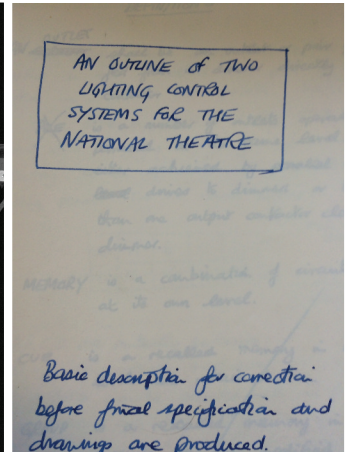
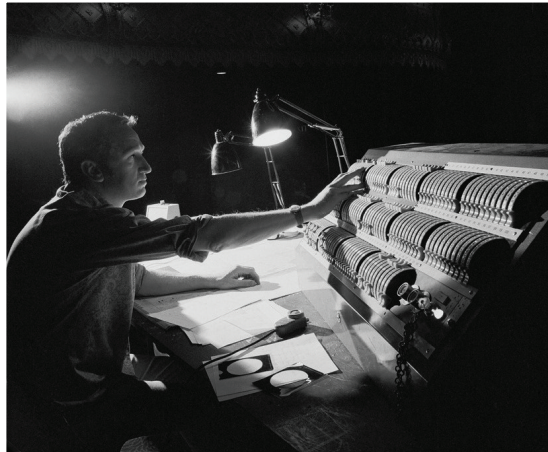
The Lightboard

LEDs and media servers and the like. With their versatile editing tools and powerful customisable displays, they are clearly a world on from Lightboard.

And yet there is still only one interaction at a time, one channel control keypad going through one level wheel, unless you take the time to set up submasters and deal with all of the problems of using them. And, however you make a cue, using channels or groups or subs or magic sheets or whatever, when you press record it collapses into just hundreds of channels at levels, and when you come back to edit the cue it's up to you to figure out all over again what's on and what needs to be changed. This feels like a retrograde step...

Lightboard is obsolete now, of course. We dream of making it work, but we doubt we can. The console on show at PLASA, it turns out, was not from the NT but from the Royal Opera House, and while we have the desk, we don't have the corresponding PDPI I. Even if we did, the software for it is probably long lost.

So it's just an object of fascination: fascinating to behold in person – even though it wasn't theirs, the recovered console has been adopted by the National Theatre, which is buffing it up to go on display as part of the building's 40th anniversary celebrations – but also fascinating because of how it evolved the way that we work. As David Hersey, who lit many of the NT's shows of the time, notes: "Lightboard heralded the start of seriously lighting over rehearsals; with 600 dimmers, we could begin to use one lamp per channel." On the stalls control, another



Pictured: The console found, top left and right, was not from the National Theatre but from the Royal Opera House; bottom left, the National Theatre/Old Vic's Robert Ornbo at Strand's lighting panel (© Richard Pilbrow); bottom right, 'An outline of two lighting control systems for the National Theatre'

tool now lost to us, he comments that it was 'an absolute joy to use – there were two board ops, so on many occasions all three of us would be banging on both desks trying to keep up with the rehearsal'.

All of us who do lighting owe a debt to Lightboard, to Richard Pilbrow and Dick Brett for specifying it, to the National Theatre board for supporting it, and to that team of lighting-loving engineers at Rank Strand who, against the odds, at the edge of possible, actually made it work.

A video of the full PLASA talk can be found at www.theatre crafts.com/pages/home/archive/talks-seminars/talks-september-2016 More information about Lightboard can be found at www.theatre crafts.com/pages/home/archive/equipment/detail?id=6027 A related talk about the history of computers in lighting control, held at the National Museum of Computing in Bletchley, is at www.theatre crafts.com/pages/home/archive/talks-seminars/talks-september-2016 To support the Backstage Heritage Collection and its Theatre crafts website, visit www.gofundme.com/bhcupdates



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