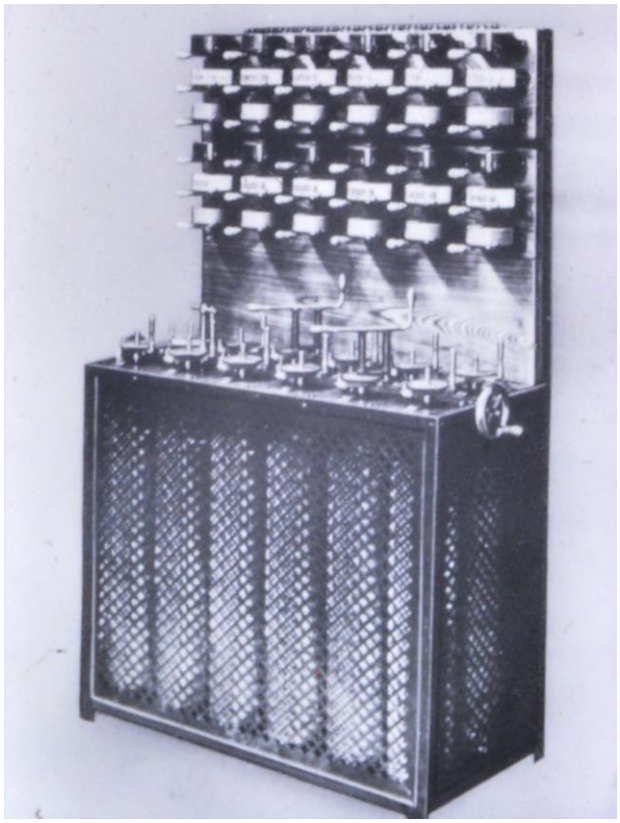
On Inertia: A History of Tracking vs Presetting in Stage Lighting Controls

Dr David R. Bertenshaw V2 8th February 2021

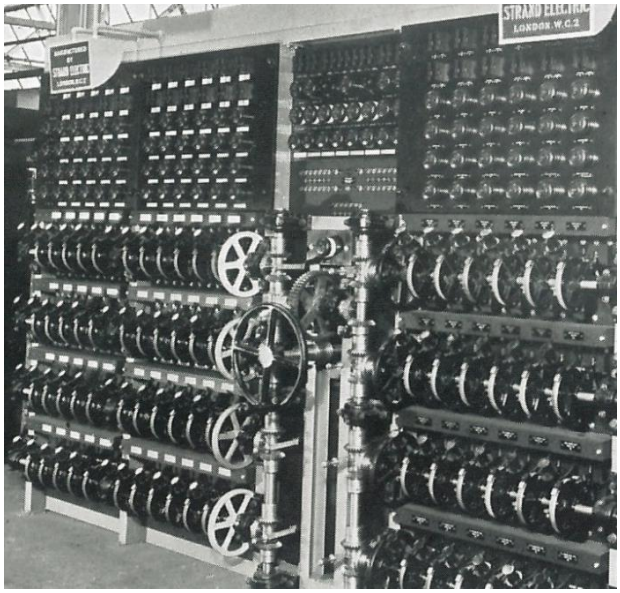
To track, or not to track, that is the question:
Whether 'tis nobler in the eye to suffer
The ups and downs of outrageous plotting,
Or to take arms against a sea of move cues,
And with a preset, end them!
(apologies to WS)

In 2020 Rob Halliday privately asked a simple question, 'Where did "Record" come from on memory lighting consoles?' He initially meant just the literal word, however discussion then expanded to the semantic, what was being recorded and why? Was it the state or a change, which further expanded to questions about dimmer inertia and how and why state, preset, move and tracking approaches to stage lighting recording evolved. This essay is an attempt to evaluate the way developments in the 20th century have influenced the question.



Siemens early (first?) electric stage lighting control board with resistance dimmers, 1881

Since their inception, direct operated electrical (and gas) dimmer boards, having only one handle per dimmer, were 'tracking' with mechanical inertia in that the handle and thus setting, which remained stationary until moved. Lighting was designed as a series of static pictures, historically often by the scene designer, with all dimmer levels recorded per cue as a 'state plot'. However this did not assist performance. Having limited hands, operators had to translate a state plot to a 'track plot' of only the changes for each cue, a series of instructions to move only certain dimmers to new levels. Since a dimmer could only physically have one level, as each cue executed in sequence this equated to the modern parlance of 'latest takes precedence' (LTP) operation.

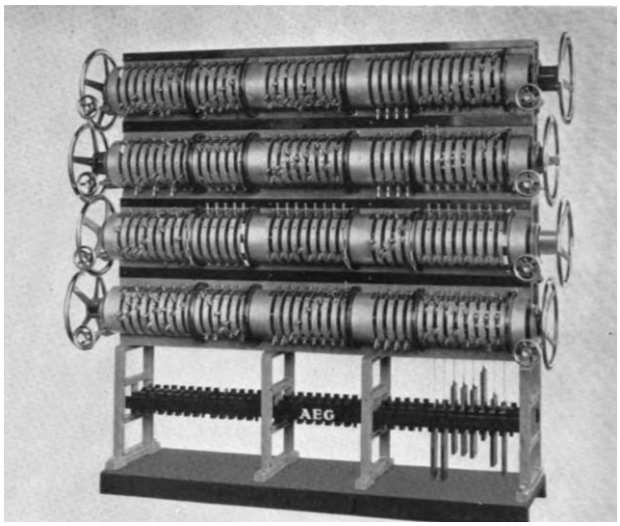


Strand Grand Master board with directly operated dimmers, UK 1931

In addition many early boards, including electrolytic dimmers, had shaft masters to which the dimmer handles could be locked. This allowed several dimmers to be moved in unison as a colour group, but all in the same direction and amount per

shaft. An example of this was the Strand Grand Master.

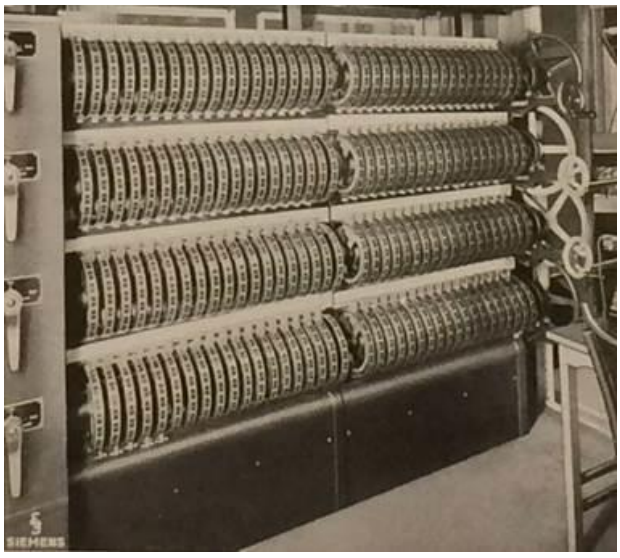
Initially such grouped dimmers had to be manually disengaged at their intended level. However tracker wire operation (flexible steel cables) common from 1890–1950s, enabled the control handles to be remote from the dimmers (electrolytic, resistance or transformer), thus smaller and more adaptable. Consequently by 1911 Berlin Opera had a 132 way AEG board with regulator handles for each dimmer which could be engaged to move and stop at a preset level (separate for up and down). However all still had to move in the same direction as their shaft.



AEG tracker wire, presetable regulator control, Berlin Opera, 1911

Another step forward was Siemens' 1926 bi-directional regulator handle. With internal counter-rotating wheels, this could be selected to move up or down for the same shaft rotation, as well as stop at a preset high or low level. Thus by turning the master wheel (always the same direction) the new state would appear, be it either a selection of channels moving, or every channel to a new preset as a complete crossfade. AEG copied the idea soon afterwards and VEM in East Germany continued manufacturing such controls until 1974. This was before Bordoni and Salani auto-transformer dimmers, which arrived in c1930 and used the same regulators.

These German systems were probably the first to offer full presetting, in that the next preset level could be adjusted without disturbing current levels. This was of course still shaft mastering, so some lights would stop fading before others depending on relative change, giving an inelegant crossfade. It was a bit more complex than with preset fader levers, in that operators had to set either a high or low stop, depending on direction of next travel. These systems also allowed processional cues, in that one could preset the destination stops ahead of the cues. Then once the shafts were in motion (they could be motor-driven), individual, and if deft groups, of dimmers could be engaged to start moving one after the other, albeit at the same rate.

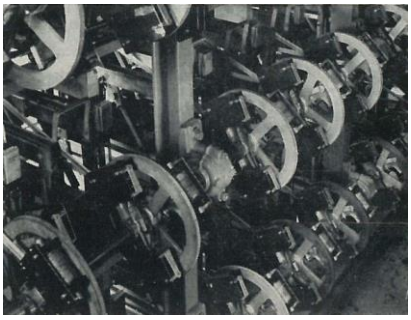


Siemens bi-directional regulator handle and controls, Germany c1926

In the USA there were some early systems of motor-driven dimmers, where each dimmer had a motor. However there is no evidence of presetting (which would have needed complex servo systems), just remote controls. In the 1920s saturable reactor dimmers were developed, but these still needed large variable resistances to control them so remained directly operated lever-per-dimmer. Also in the USA there were some shaft coupled dimmers that could be set to trip at a level, but again only with all on that shaft moving in the same direction. The Strand Grand Master from 1931 similarly had self-release

handles, but these merely released at full or off, not at a preset level.

Strand Electric launched Fred Bentham's Light Console based on an organ console in 1935, with memorised groups that could be selected to move. The resistance dimmers were driven by pairs of electromagnetic clutches for up or down movement, the direction controlled by the operator on the keyboards. The Light Console was thus as intrinsically tracking as previous manually controlled dimmers. Normally only the dimmers to be changed in the cue were selected, special operations were needed to change all dimmers. By now the term 'console' was becoming an alternate to 'board', implying a seated operator.

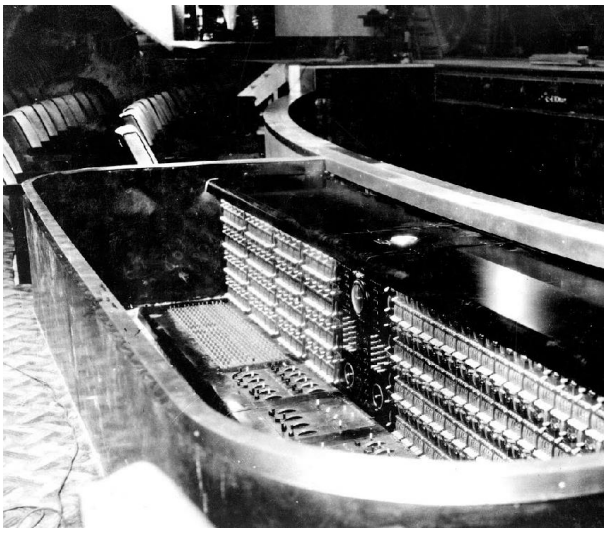


Strand Light Console with clutch-driven dimmers, Drury Lane, c1950

The Light Console's drawback was that it provided almost no control of level except by eye, so was very difficult to use for dramatic lighting design (except colour music). Indeed its instructions made clear it was intended for 'spectacular lighting' rather than 'meticulous design'. However it made history with its idiosyncratic approach which remains of interest to this day, while the electromagnetic clutches and organ stop memories were repurposed 20 years later for a more repeatable control.

The invention of the thyratron allowed saturable reactor control by low current, and in 1929 General Electric in the USA built the first two preset thyratron/reactor dimmer systems. To maintain a constant dimmer level now required electrical 'inertia' and thus inevitably a fader lever or dial potentiometer. This was probably the first change from track performance plotting to multi-preset plotting. Changing the control source from one preset to another prevented any means of holding a circuit level unchanged, other than by copying all unchanged levels forward to the next preset. As a result the initial state plots became the operating plots.

From then on multiple presetting held sway for electrical remote control consoles – except for Siemens as discussed below. But multi-preset operation allowed proportional crossfades for the first time. Other similar systems followed through to WW2 though the high cost of such systems meant that most theatres continued to use simple resistance or transformer dimmers.



GE five preset console, Radio City Music Hall, 1932

Post WW2, Izenour with Century Lighting in the USA introduced the first wholly thyratron dimmers, with a ten preset control. Strand Electric and then AEG followed with their thyratron dimmer consoles, all multi-preset. In all these, since the electronic dimmer needed a constant control signal to stay on (the electrical inertia), the user always had to copy the current level to the next preset for channels not changing in a cue to avoid inadvertent change. Most preset consoles provided multiple group control within presets to assist tracking, by holding some channels constant while others changed. However this was always inflexible in use due to the hiatus when channels are added/removed from a group.

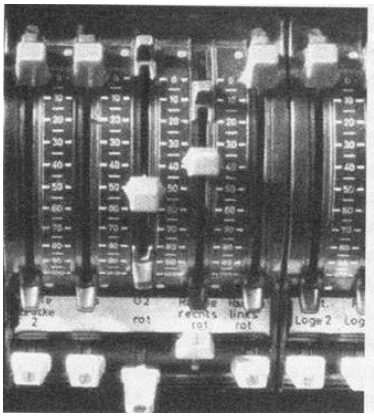
The demise of Strand Electric's preset oriented 'Electronic' thyratron system in 1956 caused them to return to motorised, clutch-driven, resistance and transformer dimmers, but now with servo feedback

control of level from preset faders using polarised relays. This resulted in systems C, CD & PR. Since the dimmer had mechanical inertia again, the best of both worlds could be achieved, a full presetting capability with freedom and memorisation of which dimmers to move. The group memories (Compton couplers, aka 'pistons') provided a particularly convenient facility for selecting processional fades. But like the Light Console, they were shaft mastering, so still gave inelegant crossfades.

Strand system CD, two preset console, with clutch-driven resistance dimmers, Sadlers Wells, 1960s

Siemens decided against developing thyratron dimmers and in 1956 perfected the voltage controlled, magnetic amplifier dimmer (better than saturable reactors but more complex). In particular the dimmers were controlled from their 'Living Lever' console, which had ranks of small clutch-controlled channel faders, driven from common motorised shafts. These bi-directional faders directly controlled the dimmer levels and could be motored to any of four preset levels, using a polarised relay control. Like Strand's system C, it had the advantage of mechanical inertia of the fader, could track levels and still provide a multi-preset scene change, with individual channels or groups set to move or not move. Despite the very considerable expense, it was popular in Germany and even made it to the Sydney Opera House. Later iterations under the Sitralux name used punched cards and ferrite core memory to provide unlimited presets.

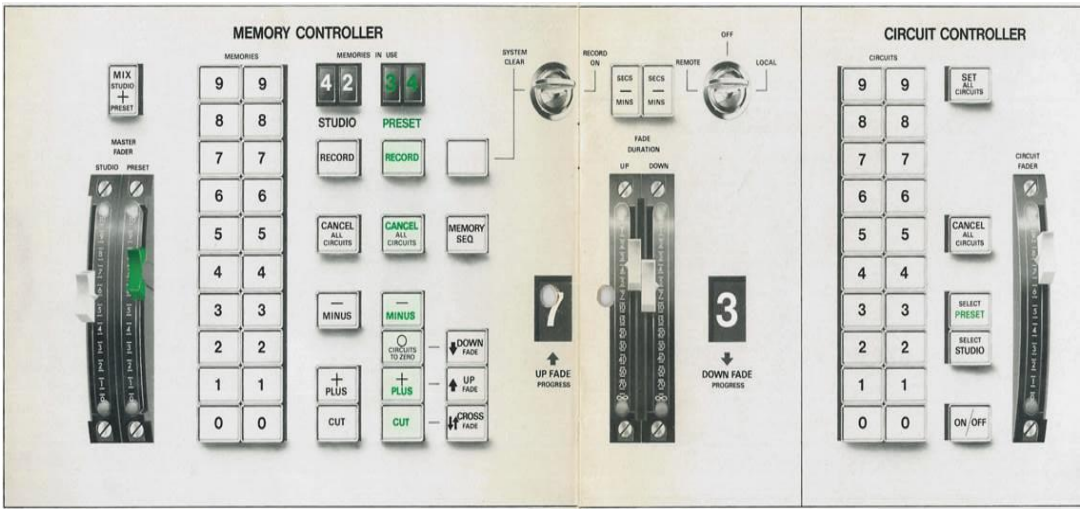
In 1959-60 the thyristor liberated stage lighting dimming, rapidly replacing all other technologies. In the USA and Europe, the control invariably consisted of multiple presets, usually with some grouping. Strand Electric in its C/AE4 (System C, All Electric, 4 presets) attempted an emulation of inertia though a complex scheme of memorised grouping with transfer to an active park group. This used the previous Compton couplers to record the groups. However since it really offered four presets, it was actually a preset board with a group control able to bring up and park, or take down lighting groups, but not fade a group between levels other than by a crossfade to a new preset.



Siemens magnetic amplifier console, 1959

In the preset era, there was some variation in how multiple presets co-existed. In some cases only one preset could be active at a time, and often proportional crossfade was provided between chosen presets. In others, and more especially with the arrival of thyristor dimming, multiple live presets were permitted and the interaction simply resolved with diode gating of the control signals, providing 'highest takes precedence' (HTP) operation.

A notable exception were some current controlled Grossman dimmers in the 1960s, which summed the presets. This provided a perfect dipless crossfade between two presets, but the tendency for lights to become brighter than plotted if more than two presets contributed meant it was not generally adopted.



Thorn Lighting Q-File console, c1970

Computer punched cards were pressed into service to first provide unlimited preset memories as early as 1959 by Century and 1961 by ASEA. Their cumbersome and unreliable technology prevented broad adoption. In 1965 Strand Electric launched probably the first electronic memory console, IDM (Memo-Q in the USA). This system, and its update MSR in 1971, operated as a simple two playback preset console. Strand claimed that IDM allowed endless processional (follow-on) cues but admitted that in reality one had to pre-record each step as a complete scene. This curiously still allowed a manual tracking mode if each new cue was reset on the faders then copied to the playbacks as needed. But 250 instant access preset cue memories meant it was never used other than in emergency.

Then came Q-File in 1966. The UK's BBC had been an extensive user of Strand's System C, which offered memorised groups of lights that could be selected to move to one of two preset levels or off. But now the BBC wanted electronic memory controls. While early TV was less interested in extensive artistic lighting levels, it needed pre-recorded 'looks' for a wide variety of shots, often in an multi-set studio, thus needing multiple balanced groups acting independently. Strand's new IDM system was no use since it provided only a single complete preset for the whole studio. In response to the BBC's need, Tony Issacs of Thorn Lighting studied the Lighting Designers (LD) actually operating system C and designed an electronic emulation of the system, i.e. a single electronic Studio store, now having digital inertia, driving the dimmers. This store could be added to, subtracted from or faded to by memorised scenes.

In totality he went much further, and essentially designed the modern memory lighting console; many of today's users would still be very happy with it (though less with the three large racks of electronics needed). The key to its facility was that each channel had a recorded level plus ON/OFF state. Move fades only changed channels that were ON in the Preset store. If a channel was OFF in Preset (regardless of level), it only affected the Studio level for a crossfade. This console finally brought together all strands of operation, move cues which only changed the lights that had to change, tracking the rest, a multi-preset crossfade capability for complete scenes, and proportional fades. But it also introduced the complexity of a channel having both a level and on/off value.

Operationally the Q-File playback also permitted endless processional fades, by simply adding the cue to the Preset and running the UP and/or DOWN fade again. Every new cue started would reset the fade controller, but channels only in the previous cue(s) would continue, as if on a conveyor belt. All shared the same change rate, but their own start and end times. If one didn't want to fade in the cues (early TV in-shot lighting changes were rare) one could directly Plus or Minus the cues into the Studio store, each being the lighting for one shot in one area of a studio. There was also blind plotting and recording via the Preset store, plus ability to control and record lighting in two areas of the studio independently by making the Preset store live (but you lost fading ability). Halliday wrote (LSI, August 2012) that Q-File's key invention was the single motorised fader for channel control, I would suggest it was the new and very liberated fade processing capability that was equally or more important.

In 1971 Rank Strand introduced DDM, the first computer-based memory system. In principle this was a two-playback, highest-takes-precedence memory system with timed crossfaders for each

playback. However each playback had the ability to perform move fades, being either a LTP, HTP or dim (to zero) for those channels on (in this case above zero) in the preset store, as well as a normal crossfade to a preset state. Move fades could also be started processionally, albeit they all took the same fade rate control. While a show could be plotted as a series of tracked changes, the underlying assumption in the system was that preset operation would be the norm.

Strand DDM console, c1973

After DDM Rank Strand launched MMS in 1973. This had an optional Rate Playback in which some may see a resemblance to the Q-File. The objective was to win back the UK TV market as well as capture a growing theatre market for sophisticated memory controls. Consequently the fade processing worked almost the same as Q-File, with 'conveyor belt' processing for each new state added/subtracted from the Preset. Like DDM it dispensed with the complexity of a separately recorded ON/OFF status, a channel was ON if >6%. Thus if you chose, one could plot a long succession of moves, permitting tracking, and same-speed processional cues.

The ON/OFF facility was not totally dropped in MMS. Since in reality the BBC mostly used it on the channel control to turn on and off lights at their recorded level, the facility was moved to the Channel control, which saved the last recorded level for every channel.

Strand MMS Rate and Manual Playbacks, 1973

In addition the Manual Playback was not just a simple two scene memory preset (albeit with adding/subtracting capability). Selecting the orange left arrow button caused the contents of B store to be copied to the A store when the crossfade to B (fader top) was complete. Thus bringing the faders back to the A end caused no change, a new or tracked cue part could then be added or subtracted to B, and another crossfade run. This meant B store always acted as the Preset, A store always as the Stage providing electronic inertia. A tracked plot would work, however overlapping processional cues could not be run. Did anyone use it – did anyone care?

Strand Lightboard, UK National Theatre, 1976

In the same period Richard Pilbrow and Richard Brett of Theatre Projects had specified the National Theatre Lightboard, which Rank Strand engineered in 1975 (installed in 1976). Like Q-File this used a single Stage store for the whole board (multiple MMS playbacks were HTP) with only one level for each light, i.e LTP. It also had the ability to

simultaneously run up to 12 differently timed, up and down move fades as part cues, so processional cues could finally work properly. However individual part cues were always operator initiated on the philosophy that human synchronisation with the drama was imperative. Again tracked plotting was possible, but there was no support for jumping back or forward in a tracked cue sequence other than, like all other boards, running forward from the last full preset (crossfade) cue.

In the USA, thyristor dimmers, with preset manual and some preset memory consoles, were in almost universal use across most provincial, college and municipal theatres in the 1970s. Even the eclectic 1973 US Skirpan AutoCue with light pen channel control ultimately offered only successive crossfades. Strand Century's Multi-Q in 1976 offered three dipless crossfade units, thus one could achieve a limited move cue effect on top of another playback holding the static lighting, but it was not easy to plot these.

However up to 1978, the available US consoles were making no impression on Broadway. Here the old 'piano boards', consisting of ranks of manually operated dimmers and their union labour masters, still held sway. In the right hands (and very many hands) wonderful lighting could be done – literally offering any light to any level at any time – but the results could also be awful with casual labour. The ability to finally claim Broadway use would be a powerful marketing tool for any company. So Strand Century President Wally Russell sent David Cunningham (VP of R&D) to sit with the Broadway LDs to find out what they really needed, and what could force a change. Cunningham watched as designers had to dictate to the electricians (not lighting technicians) exactly what they wanted, e.g.: '23@5 and 27@7 and 45@full for cue 11 in a count of 8'. This gave rise to both command line console interaction and only recording the changes in each cue. The piano boards had always needed track plotting by the LDs who were fully used to it, they had to be.

From this was born Light Palette in 1978, the first memory tracking console, where the normal recorded cues were solely the changes to the previous state. Even though each cue was just the changes in that cue, the user could jump (GoTo) to any cue out of sequence and it would compute the correct end state. It recorded all the attributes of processional tracked fades, with selectable delays to up/down fades, providing up to 6 part cues. The concept of multi-part cues was also formalised in this system, in that the allocation of channels, levels and times to each part was recorded in one compound cue executed by a single GO, rather than a succession of cues.

Since Light Palette was intrinsically tracking, it meant that one had to normally record the show in the performance order. This needed two new recording features in a tracking console, 'Cue Only' and 'Block Cue'. Cue Only allowed a cue to be inserted or deleted in a tracked sequence without disturbing the expected states for later cues, by automatically adjusting the following cue in sequence. Block Cue recorded a complete preset state, unaffected by previous cues, and acted as a starting point for a new tracked sequence.

Strand Century Light Palette, 1978

Light Palette was not strictly the first memory console on Broadway, EDI had installed an LS-8 for 'A Chorus Line' earlier in 1975. To break the union hold, the LD Tharon Musser had to prove the electricians could not physically operate her design fast enough. Probably since this was a standard preset-oriented board, EDI didn't win the reward of 'first mover', it was Strand Century that finally provided an equivalent of Broadway lighting practice. Piano board use finally ceased by 1981.

Intrinsically tracking consoles did not initially gain much interest outside Strand. The majority of lighting designers were accustomed to scene-by-scene design, for which preset consoles were most convenient. Light Palette also had to revert to normal preset (Cue Only) recording for TV use (which became a user choice from 1987), due to the mistakes that can arise from non-sequential recording and playback.

At the same time as Light Palette's arrival, an ability to interrogate and edit the tracking of channels was offered on Colortran's 1978 'Channel Track', with a limited tracking facility on its 1986 'Prestige' console. ETC then developed an obsession to beat Strand Century in the US market via Broadway, so similarly launched the world's second fully tracking console in 1992 – the 'Obsession'.

Back in the UK, Rank Strand launched the Galaxy system in 1980 which emulated the Lightboard, but at a much more affordable price, similarly with multi-part fades at differing speeds. While a tracked show was quite possible, it chose not to support tracking recording in the manner of Light Palette. This reinforced the developing schism between Strand US tracked plotting and Strand UK preset plotting.

Siemens Sitralux B40, UK Royal Opera House, 1986

One must note Siemen's B40 system from 1981. While still a preset system at heart, it offered the ultimate in multi-part cues – each channel could have its own fade and delay time in each cue! This flexibility was not emulated by others due to the complexity of managing it until well into the 21st century.

As a postscript, fast forward to 1995 and the launch of Strand Lighting's 430, 530 and 550 consoles. Here on the same hardware, there was a choice of either a preset oriented 'GeniusPro' or tracking oriented 'LightPalette' software. Rather than excessively compromise either, two suites of software were designed sharing the common hardware. Finally Strand UK was backing both horses!

The development of powerful microprocessors in the 1980s enabled many memory lighting consoles to enter the market, whose quantity and lack of historical archives makes further analysis for coherent patterns impractical. In May 1986, LSI magazine printed a 'Memory Control Technical Comparison' chart where 45 different consoles were compared by key features. However the only fade-related features listed were 'Number of Playbacks', 'Number of simultaneous fades' and 'Number of submasters'. The recording and playback operational philosophy did not feature, and presumably to the authors, did not matter?

Despite now 50 years of the ability of memory lighting consoles to record and replay both states and multiple and overlapping move cues, Halliday has noted that the dichotomy of what a recorded cue is remains unresolved. Is it a change in the lighting, or a state of lighting? Conceptually a lighting cue is the same as any other stage direction, a call for something to start (or stop) happening.

Tracking consoles define a cue as part of a long and potentially complex change of lighting, assuming that a performance is a linear process and the lighting cues will be called in strict sequence. Recognising this, tracking consoles generally offer a GoTo cue function that computes the correct end state from preceding cues in case of a non-sequential cue request.

In simple preset systems a cue can be equated to the lighting state memory to be presented, allowing cues to be played in any order. However preset consoles usually also support move fades to make restricted or overlapping changes, so if these cues are not replayed in sequence, incorrect levels can also result. Curiously such preset consoles have not offered an ability to directly jump to the result of several move fades. It has always been up to a competent operator to know how to achieve this. It is however a rarer event, as on a preset oriented console, most cues will be complete presets.

On both types of console, if a cue is called out of sequence, incorrect levels can result if levels from preceding cues have not been established. It thus remains important that the LD or their programmer has a good cognitive model of the console's mode of operation to get the best out of it, and avoid unexpected results.