24 September 2026

MIDI 2.0

The Musical Instrument Digital Interface (MIDI) arrived in 1983, with an update to MIDI 2.0 appearing in 2020. The purpose of the interface, the transfer of musical performances and other musical data between computers, synthesisers and other devices remains unchanged, although the new version provides greater resolution and precision for all forms of data, two-way communication and handshaking between devices, the exchange of settings between devices, the transfer of data over USB and a new 8-bit data format that replaces the earlier 7-bit format, all the while maintaining the compatibility necessary to control older MIDI 1.0 devices.

Unlike MIDI 1.0, this new version does not support the original hardware interface, except when driving a MIDI 1.0 device. The older interface is connected by 5 pole DIN plugs, with optocouplers in the receiver and operating at 31.25 kbit/s,. This is perfectly adequate for older and slower musical devices, especially since the data in MIDI 1.0 is optimised for speed. For comparison, it's worth noting that the original form of USB didn't appear until 1996.

Some people have bemoaned the lack of a special interface for musical devices in MIDI 2.0. They perhaps fail to understand that the physical hardware and firmware 'transport layer' used to connect devices in all modern systems is oblivious to the actual data being transferred. Today we move text, pictures and videos over USB, Wi-Fi and Ethernet without giving any thought about interfaces. The same thing will inevitably happen to MIDI.

Whether USB-C is robust enough for stage use is a different matter, although Neutrik offer a latching version, StarTech and others make a connector with a single locking screw, and others do a version with two screws. No doubt one these will become the standard in due course. Meanwhile, for Ethernet wiring, Neutrik make the EtherCon, a robust connector similar to a standard XLR plug.

23 September 2026

Musical Progression and the Spirit of the Age

The fifties and sixties were times of hope, with the horrors of Belsen and Hiroshima behind us, an age of looking forward, science pushing us onwards to a new prosperity, a clean and modern world in which the darkness of the past would be swept away forever.

It was an illusion, of course, but the arrival of the National Health Service, the closing of dirty old railways and the building of new motorways and towns, along with the concept of shared ownership, at least gave us the impression of moving forward. That movement was reflected in the music of the latter end of the period, especially in the pure electric guitar sounds of the Shadows, or the sky-reaching tones of Joe Meek's production of *Telstar* by the Tornados of 1962, pushing progress yet further into the realms of outer space.

To myself, as an eleven-year old, the theme to *Doctor Who* was similarly exhilarating, with its pulsating rhythm and pure-sounding melody, to which a child of that age could easily jiggle around to. But I soon grew out of *Doctor Who* and I only heard of the Workshop again in my teens, mainly because the *BBC Sound Effects No. 1* record was extensively employed in school dramas. At this point my musical interest was that of the school 'discos', aided by copious coloured oils in a light projector. Bands of interest included Pink Floyd, especially the 1968 track *Set the Controls for the Heart of the Sun*, The Soft Machine, The Velvet Underground, Deep Purple and, of course, the deep philosophising of The Moody Blues.

Electronic music frequently left me cold. I heard Wendy's Carlos's *Switched-on Bac*h of 1968 years later, but her original work for *A Clockwork Orange* of 1971 had far more impact, in particular the track called *Timesteps*. This later album blended various musical forms, including the humanising use of her voice and vocoder, and escaped the tiresome rigidity of Bach, his music seemingly more of an exercise in building musical structures than anything else.

Mike Oldfield's *Tubular Bells* of 1973 sparked my interest, as it was a truly original work, despite its simple form. And some of Mike Batt's albums, which crossed over between popular and classical styles, interested me in the eighties, especially *Schizophonia*.

Emerson, Lake & Palmer passed over an even wider bridge between rock and classical, particularly in their early albums, *Emerson Lake & Palmer*, *Tarkus* and *Pictures at an Exhibition*, but also in *Brain Salad Surgery*, which features a stunning rendition of *Jerusalem*. And then there was Hawkwind who, like Pink Floyd, created 'space rock', music of an 'hypnotic and otherworldly sound'. The album *Warrior on the Edge of Time* is probably the most 'Radiophonic', with its processed voice calling us across an unknowable space.

Having ventured further through some of the synthesised versions of classics by Isao Tomita, I came to the conclusion that I actually preferred real instruments or something entirely different.

So, for the former I explored the classics, including Beethoven and Tchaikovsky, as well as Ralph Vaughan Williams, particularly liking *The Lark Ascending* and *Fantasia on a Theme by Thomas Tallis*.

For the latter I went for King Crimson, described by Jimi Hendrix as 'the best group in the world'. Their most well-known track is *21st Century Schizoid Man*, a prophetic and alarming piece, used as the opening track of *In the Court of the Crimson* King, their first album. Of their later records, *Islands* is rather different, including a track called *The Letters*, with amazing dynamic range and spell-binding poetry. There's also *Starless*, from the album *Red* of 1974, which is perhaps an anthem of the loss of hope at the end of the sixties, sadly expressed by a rather quiet mellotron playing in the background.

One of King Crimson's members was Robert Fripp, who later paired up with Brian Eno, keyboard player for two albums by Bryan Ferry's band Roxy Music, to produce the album *No Pussyfooting* in 1973, a minimalist work based on reel to reel tape loops and tape delay.

Eno produced *Another Green World* in 1975, described as 'a universally acknowledged masterpiece', followed by *Before and After Scienc*e in 1977. Having worked with David Bowie, further unusual collaborations or minimalist works were to come, the most famous being *Ambient 1: Music for Airports* of 1979, which actually defined ambient music. To sit and listen to it is very hard!

It would, of course, be foolish to write about electronic music without mentioning the Radiophonic Workshop, of which there are three 'standalone' albums created by individual composers. One is Peter Howell's *Through a Glass Darkly* of 1978, aptly described as 'a stunning original album of synth-heavy prog rock', including a well-known track called *The Astronauts*, which takes us again to the future and to outer space. And then there's Paddy Kingsland's *Supercharged* of 1974, a more commercial, twee at times, and pop-orientated album, but including a fine track called *The Earthmen*. And lastly, there's *Future Perfect* of 2023 by Elizabeth Parker, which reaches into the deepest atmospheres of electronic music.

Whatever your views on these albums, they symbolise the huge contribution that these composers and others at the Workshop made during the forty years of the department's existence. Other early albums containing their 'routine' work in radio and television include *BBC Radiophonic Music* of 1968, with music by John Baker, David Cain, and Delia Derbyshire, *Fourth Dimension* of 1973, presenting some of the output of Paddy Kingsland and *The Radiophonic Workshop* of 1975, followed by many more albums and compilations. There are also the five Cavendish Music albums, released in the 1990s, which contain Radiophonic soundscapes and sound effects, each grouped into a theme.

Although these collections form an archive of the various musical styles produced at the Workshop, it remains my firm opinion that such work is best heard in its original context, within the radio show or television programme for which it was designed.

And the music of today, or even of the nineties? Beyond my time or understanding, I'm afraid, especially if it involves rap!

21 September 2026

Wires, Wires and More Wires

By 1991, all the studios at the Radiophonic Workshop had been equipped with at least a pair of Yamaha *DMP7* mixers plus an Akai *DP3200* matrix. This meant that the physical wiring of the studio was largely fixed, although other changes were possible via MIDI.

All the connections to the matrixes were via standard quarter-inch two-pole TS (tip, sleeve) ‘mono’ jack plugs, matching the sockets on most devices. Any equipment with three-pole TRS (tip, ring sleeve) ‘stereo’ sockets, in this instance used for balanced circuits, had to accept a mono plug regardless, forcing it to work in unbalanced mode. Devices that had XLRs or ‘RCA’ phono sockets were easily accommodated by using commercially-available ‘barrel’ adaptors.

Other cables were required to test out equipment and to make immediate or temporary changes to installations. However, these were reduced in number to 5-pole DIN to DIN, XLR male to XLR female, XLR male to mono jack plug, XLR female to jack plug and jack plug to jack plug, the latter incorporating an adaptor at one end that allowed it to also be used as a jack plug to phono plug cable.

20 September 2026

Dilemmas in Digital

If you walked into a studio at the Radiophonic Workshop in the late eighties you would have found a computer surrounded by an array of boxes interconnected by cables, but in such a studio today the computer *is* the studio, sounds, music and data simply being passed between elements of software that often echo the hardware of the past. And modern digital mixing consoles are also a form of workstation, with activities implemented entirely within the device.

But when it comes to connecting together physical digital audio circuits it's very likely that the problems faced by the Workshop then would be much the same today, just with different hardware.

Beginning in 1987, the Workshop embarked on creating the 'circular studios' originally envisioned by Peter Howell, a MIDI-based system using Yamaha *DMP7* and *DMP7D*s as the mixing elements. The first installation was created for Elizabeth Parker to see if a composer who preferred creating music rather than suffer the trials of technology could take to it. She did, and it was a total success.

The main installation consisted of four *DMP7*s connected to a *DMP7D* master mixer via the 'cascade' outputs of the former and into the eight digital inputs of the latter, plus an 'auxiliary' *DMP7* mixer feeding into the cascade input of the master mixer.

Problem Number 1: It was thought that connecting the *DMP7* cascade outputs, which appeared on 8-pole DIN sockets, to the inputs of the *DMP7D* via its 25-way 'D' socket would be easy, since both used the Yamaha 'Y2' digital format. Unfortunately, the *DMP7*'s output, a standard RS-422 signal, plus a word clock in the same form, was configured for stereo whilst the inputs of the *DMP7D* were made for eight mono channels. This meant that any attempted connection conveyed only the left-hand channels.

Yamaha, keen to see the Workshop succeed, created a CIU (custom interface unit) to correct the problem. It was likely made from parts used in other Yamaha interface boxes, but it worked perfectly.

Problem Number 2: This difficulty emerged in the later studio created for Peter Howell. For marketing reasons, all 'consumer' digital products, such as the *DMP7*, were limited to a sampling rate of 44.1 kHz, whilst 'professional' devices, such as the *DMP7D*, could operate at either 44.1 kHz or 48 kHz. Having a mixture of these devices meant the studio's sampling rate had to be fixed at 44.1 kHz.

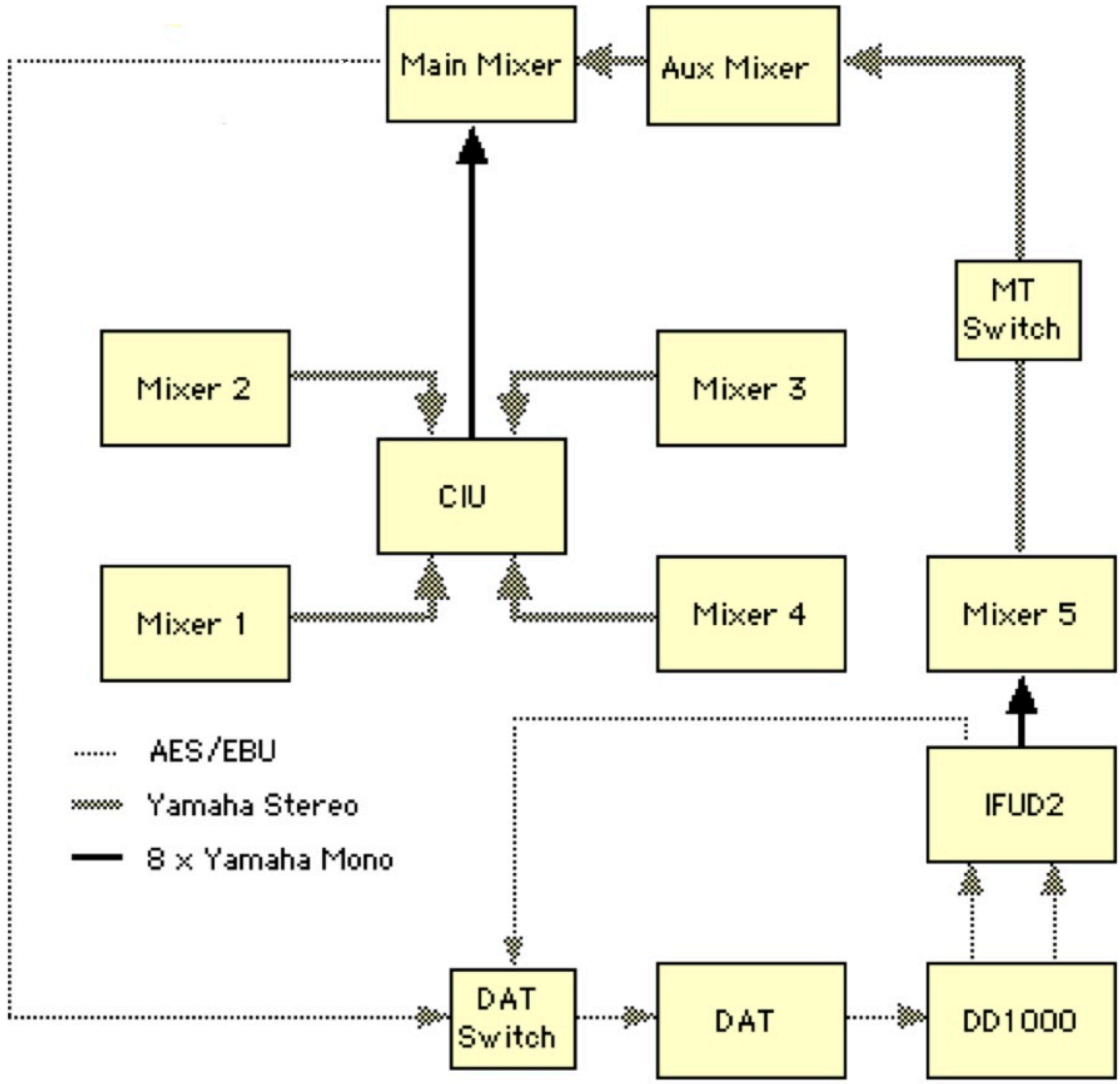
Problem Number 3: Similar to the above, consumer devices were designed to operate on digital signals that had been encoded with 'pre-emphasis', sometimes known as 'emphasis', which boosted high frequency sounds before conversion. Professional devices, however, could work with digital data that was either non-emphasised or emphasised. As the *DMP7*s were a domestic product, the entire studio had to operate with emphasis enabled. Worse still, the Akai *DD1000* (see below) ignored the emphasis 'flag' at its AES/EBU digital input, and therefore produced a 'hissy' analogue output.

Problem Number 4: The standard Sony *PCM2500* DAT recorder would happily synchronise with an incoming AES/EBU audio stream during recording, but in playback and other modes it sent an internally generated clock over its AES/EBU outputs. The machine was later modified to accept the incoming clock in all modes.

Problem Number 5: The introduction of an Akai *DD1000* four-track optical disk recorder added serious complications, as shown below. An extra *IFUD2* interface supplied by Yamaha fed the four outputs of the *DD1000* into channels 1, 2, 5 and 6 of 'multitrack' Mixer 5. This *DMP7D*'s output then fed the cascade input of the Aux Mixer.

The 'MT Switch' allowed muting of 'multitrack' Mixer 5's output, but did not interrupt the AES/EBU 'master clock' circuit. This clock, generated by the *DD1000,* was passed through the *IFUD2*, Mixer 5 and the Aux Mixer and finally to the Main Mixer and CIU.

This design allowed digital transfer of outputs 1 and 2 of the *DD1000* to the DAT (via the first AES/EBU output of the *DD1000* and a buffer in the *IFUD2*) and digital transfers in the opposite direction, although other recordings on the *DD1000* were made via its analogue inputs to avoid digital synchronisation problems.



Peter Howell used this complex but effective setup for some time. In the absence of any proper standardisation of digital interfaces, the failure of some devices to behave sensibly when given a clock signal and inconsistent responses by some equipment to AES/EBU data, it was the best anyone could have possibly achieved.

18 September 2026

Generators of Sound

The history of the Workshop's output can be divided, very roughly, into three overlapping periods: the *music concrète* era of the fifties and sixties, the age of analogue synthesisers in the seventies and the emergence of digital synthesisers in the eighties. The possibility of handling sounds directly within a computer arrived at the beginning of the twentieth century, long after the closure of Workshop.

Music Concrète

Before the Workshop opened in 1958, Daphne Oram and Desmond Briscoe had already done pioneering work in radio and television, following on from the experimental projects by pioneers such as Pierre Schaeffer and Pierre Henry. This kind of work involved taking real recordings or electronic sounds and then modifying them using tape manipulation, filtering and reverberation. And the Workshop kept this tradition going all the way through the sixties, creating Delia Derbyshire's vast catalogue of work, including the oft-mentioned theme to *Doctor Who*, as well as material by Desmond Briscoe, John Baker, David Cain, Malcolm Clarke, Dick Mills, Maddalena Fagandini and Glynis Jones. Apart from the aforementioned *Doctor Who* and the innovative *Time Beat*, it would seem to appear that the greater part of the Workshop's output over this period was 'special sound', meeting the Workshop's original remit to steer clear of the dreaded 'M' word, music.

Apart from the BBC's Effects Library discs and recordings made of various musical instruments, mechanical devices, hot water tanks lampshades and other incidental objects, the Workshop used banks of test room oscillators and 'keying units' to effectively 'play' them from musical keyboards, as well as the famous B&K wobbulators.

The Analogue Synthesisers

1971 saw both the arrival of the first voltage-controlled synthesisers, the EMS *VCS3* and the EMS *Synthi 100,* ‘The Delaware’, and the departure of many people who had worked in the *concrète* style. During this decade a number of new faces appeared, including Malcolm Clarke, Peter Howell, Paddy Kingsland, Roger Limb and latterly Elizabeth Parker, most of whom were very experienced ‘real world’ musicians. Undoubtedly this gave momentum to the gradual shift towards the production of more music at the Workshop.

Making usable sounds from the earliest synthesisers was very difficult. It required a highly analytical mind or an enthusiasm for endless experimentation and the ability to easily recall the settings for that ‘great sound’ you successfully made the previous week.

The fact that these machines had keyboards really didn't make them any more musical, especially as they were at best only duophonic. Whilst natural sounds often have extremely complex waveforms and harmonics that change almost endlessly as they begin and then fade away, the use of sine waves, square waves or triangular waves in a synthesiser, filtering or adjusting these in a way relating to a sound envelope is a very crude process and certainly not very intuitive.

In 1972 the ARP *Odyssey* arrived. Although also limited to duophonic operation it had slider controls and switches to link the various voltage-controlled elements, making it far simpler to use than the EMS products with their rotary controls and patch pins: slightly less versatile perhaps, but more suitable for a true musician.

1976 saw the appearance of the *EMS Vocoder 5000*, possibly the most complex vocoder ever built, which took analogue sounds and split them into their component frequencies so as to create control voltages to operate a synthesiser, the design of which came from the original EMS *VCS3*. This allowed, for example, a human voice to perform as if it were a synthesiser. This machine was particularly popular with that 'surreal' composer Malcolm Clarke, and with Peter Howell, who used it for the legendary 'Greenwich Chorus'.

Towards the end of the seventies the first analogue synthesisers with hard-wired digital control circuits appeared. Of these the Yamaha *CS-80* was the Rolls Royce. Virtually indestructible, with a 61-key weighted keyboard, it offered eight-voice polyphony, with two oscillators per voice, as well as polyphonic aftertouch, the ability to respond to finger pressure individually on all the keys. It would seem it needed a degree of learning to acheive the best results with this machine, but it was a real musician's instrument.

In 1978, a year after the *CS-80* arrived it was the turn of Sequential Circuits *Prophet-5*, a five-voice polyphonic machine, with two oscillators per voice. Although it used analogue sound generators, this was the first musical instrument to be controlled by a microprocessor, the Zilog Z80, which also provided automated tuning and allowed the user to save up to 40 settings in a memory store. The latter was probably one of its most popular features.

In that same year Roland produced its first polyphonic synthesiser, the *Jupiter-4*, with analogue circuitry controlled by the early Compuphonic microprocessor, offering 4-note polyphony with one oscillator per voice and a keyboard equipped with 49 keys.

The Digital Synthesisers

Although first created in 1979, the Fairlight *Computer Musical Instrument* belonged to the eighties, being way ahead of its time, and a portent of what would be achieved with desktop computers decades later. Unlike earlier devices, it used microprocessors to directly handle audio material. It was unique in that it introduced 'sampling' into the English language for the very first time, replicating the earlier *concrète* techniques of the Workshop, the process of taking sounds and usefully manipulating them.

The Workshop bought the *CMI Series II* model in 1981. It included a full-sized keyboard along with a light-pen that could be used on the display screen. This later model also incorporated a sequencer and supported sample rates of 8, 24 and 32 kHz, although the sample length and sound quality was always a matter of compromise, since the sample memory was limited to just 16 kB. But remember, this was two years before Apple's first computer.

Favoured by Peter Gabriel, who helped establish the company Syco Systems (later patronised by the Workshop), it was also enjoyed by Peter Howell, who for a while used it in the Workshop's tape store.

Requiring a similar facility for Elizabeth Parker to employ on *The Living Planet,* but short of funds for another *CMI*, the Workshop purchased a PPG *Wave 2.2* paired with a *Waveterm* digital sampling system in 1982. The *Wave* stored each sound as a single cycle of a waveform in what was known as a wavetable, but also incorporated computer-controlled analogue elements, including filters. The *Wave* had 8-voice polyphony with two oscillators per voice, with the *Waveform* sampler also enabling the user to draw waveforms or to convert existing sounds into wavetables.

This period saw the emergence of some rather odd designs, including the Oxford Synthesiser Company's *OSCar*, a British duophonic synth of 1983 that used digital oscillators along with analogue filters, all incorporated in a rubber casing. Users could also draw and store waveforms. Characteristically, it was popular with Malcolm Clarke who liked the 'raw' sounds that it created.

One of the problems with the many different synthesisers emerging at this time was the lack of any way of controlling them via a single entity. In 1981 there emerged the idea of a Musical Instrument Data Interface (MIDI), which reached its final specification in 1983. This allowed performance and control data to be passed between instruments and computers. Whilst computers at this time were able to convey such simple data, they were incapable of directly processing audio material. MIDI offered a stepping-stone towards the ultimate goal of an entire studio existing within a computer.

Most of the devices manufactured during the eighties offered only 16-voice polyphony, amazing at the time, but inadequate by modern standards, especially when notes are sustained. However, some devices were also multitimbral, providing more than one kind of sound at a time. Most samplers were also 8-bit, requiring extensive filtering, usually analogue, to give a satisfactory sound. The results were very subjective, a matter of taste for individual musicians. All these limitations were the result of the primitive microprocessors used at the time and associated restrictions in memory size.

One of the very first MIDI-capable instruments was the Yamaha *DX7* of 1983. Having 61 keys, velocity sensitivity and aftertouch, it employed frequency modulation (FM) to synthesise complex and often highly musical sounds. The instrument had a range of impressive presets, but could also be programmed to create original material, an art apparently perfected by Brian Eno.

By 1984 the race for MIDI was accelerating, it becoming apparent that studios of the future would have no need for stacks of keyboards: they would be replaced by a master MIDI keyboard connected to synthesiser boxes, a computer and other devices via MIDI. And so, in 1984, Yamaha released such a keyboard, the *KX88*, a superbly built device with 88 keys, controller wheels and sockets for pedals. Almost simultaneously, the Yamaha *QX1* 8-track MIDI sequencer appeared. This had one MIDI input, along with eight outputs to connect to the synths that it controlled. Just a year later Yamaha released the *TX816*, made up of eight *DX7s* in a rack-mounted box: almost an entire studio built into one unit.

The E-mu Systems *Emulator II* came the same year, with a 61 key keyboard and the ability to sample and manipulate sounds. Featuring MIDI, it could be used with the Workshop's *Syncwriter* package to synchronise sound and picture. The 8-bit sound quality was subjectively improved by the use of advanced analogue filtering.

By 1987 most manufacturers had moved over to making only rack-mounted synthesisers. In that year Yamaha offered the Workshop the *TX802*, similar to the older *DX7 II* synthesiser, but in a box, with the ability to play eight different sounds at once.

The Roland *D-550* synthesiser, yet another rack-mounted device and derived from Roland's original *D-50*, was released the same year. This could play two parts simultaneously and had built-in effects. Also appearing at this time was the companion *S-550* 12-bit sampler, based on the older *S-50*, which could play eight parts at once. It sampled at a frequency of 15 or 30 kHz, giving a maximum sample time of 28.8 or 14.4 seconds respectively, with data stored on a built-in 3½-inch floppy disk. It could also be connected to a CRT (cathode ray tube) display to accommodate sample editing.

The Yamaha *TG55* was also rack-mounted and appeared in 1989, providing a 16-part multitimbral capacity and incorporating dual resonant digital filters, a step forward from analogue filtering.

Another rack-mounted device, the E-mu Systems *Proteus* arrived at the Workshop in 1991. This offered high-quality 16-bit samples of various musical instruments, as made for the *Emulator III*, and could play 16 parts of different sounds via MIDI. This was soon followed by its partner machine, the *Procussion*, with 32-voice polyphony, incorporating over 1,000 types of percussion instruments, including tuned percussion, and equipped with six audio outputs configured as three stereo pairs.

By the late eighties the capabilities of the Apple *Macintosh* were far beyond those of earlier machines, making it possible to compose music on the computer and play it via MIDI and associated synthesisers, but the computer itself was yet to be fully capable of creating sounds. Sadly, in 1993, *Producer Choice* came into effect, halting any further developments at the Radiophonic Workshop.

Beyond

Although some 'virtual instruments' appeared in the late nineties, the real step forward was Steinberg's *Model E* software for *macOS*, which emulated the famous Moog *Minimoog* synthesiser, operating by means of a plug-in based on *VST (Virtual Studio Technology)*. Today, there are many other such plug-ins for sound generation, audio effects and MIDI processing. Apple's native plug-in architecture, known as *AU (Audio Units)* similarly works with compatible applications such as *GarageBand*, *Logic Pro* and others. Now, some of the devices listed above can be inside your computer!

14 September 2026

Influences

Those who create music are always influenced by what came before. Recently I revisited a studio album that I had probably not listened to for decades; 'To Our Children's Children's Children' by the Moody Blues, which is considered by some to be portentous, pretentious or both, but whatever your views of its content, a highly skilled aggregation of musical styles, created in 1969, the very same year as the first moon landings and just six years after Delia Derbyshire's production of the theme tune to *Doctor Who*.

There can be little doubt that the Moody Blues were influenced by the Workshop: they used an array of different musical instruments, sound generators and other devices in a similar way and also, very importantly, played the Mellotron. Seen as a vital instrument for progressive rock bands such as Pink Floyd and King Crimson, it had the emotional impact of a string section, but flawed, badly flawed, being horribly difficult to play and with a sometimes irregular sound. And that, like the sometimes strange quality of elements of the *Doctor Who* theme, is exactly what makes it so effective, more human, but peculiar. Perhaps that is what led Pete Townshend to say 'Listening to a Moody Blues album is like being in church.'

On the The Coventry Music Museum website it says of Delia:

During her time at the BBC she was visited in her studio by a number of bands of the day, most of whom are still listened to 50 years later:

- The Beach Boys demonstrate some of her influence in the way they start to use studio effects on their *Pet Sounds* album;
- The Beatles show heavy use of tape effects, reversed tape sounds, tape editing, sound manipulation on albums such as *Sergeant Pepper* and the *Magical Mystery Tour*, following some extended sessions in her studio (ironic, given what that Decca executive had told Brian Epstein some years earlier…);
- Pink Floyd were profoundly influenced after a few sessions working with Delia.

It is very reasonable to say that Delia's influence was a hugely significant factor in the Floyd's move from their early days as a psychedelic band into one of the founding fathers of progressive rock. Indeed, if the Floyd are to be credited, along with the Moody Blues, as the fathers of prog, then Delia has to take credit for being its mother.

There is also a connection to the Moody Blues in the early work of Peter Howell, later of Workshop fame, alongside John Ferdinando. In an interview on The Strange Brew John says:

My contribution to the Agincourt album encouraged me to compile an album of my own, although it would rely a great deal on Peter's production skills. I already had a few ideas in the locker and decided to go for a concept type offering which was much in vogue. I confess to being a fan of The Moody Blues, who were huge at the time, notably in America, and I did get a bit caught up in a sort of parody of their cosmic phase. 'What's it all about, man?' just about sums it up, and of course as one gets older one does find out exactly what it is about, as one's youthful ideals quietly sail away on the wind. I have been very genuinely surprised as to how well the album has been received.

More about these early works can be found at Peter Howell Media.

'Fly Away' album by Agincourt

Pink Floyd at the Maida Vale Studios

14 September 2026

A Question of Balance

Historically the BBC used transformers at each end of an audio circuit, the ‘balanced’ signal being carried over a twisted pair of wires. Any interference was cancelled out by the transformers, an effect known as ‘common mode rejection’, with the effectiveness of this measured by its CMRR (Common Mode Rejection Ratio).

Being ‘earth-free’ or ‘floating’, no earth connection was needed, although one could be connected to a screen around the wires. Any potential voltage differences between earths at either end were irrelevant, unlike an unbalanced circuit, one with a single wire and an earthed screen, where multiple earthing paths often result in serious technical problems, usually in the form of ‘hum loops’.

A centre-tapped transformer, with the tap connected to ground, can also be used to create a balanced circuit with a good CMRR. Note, however, that earth connections are still involved and may cause complications. This arrangement is also dependent on the effective ‘accuracy’ of the centre tap at all frequencies.

Electronically balanced circuits do not always have a good CMRR. Many are simply symmetrical, offering no rejection at all, and in some instances, when one ‘leg’ of such an output is connected to ground, such as at an unbalanced input, the source injects a signal into the earth, potentially causing a variety of problems.

Shifting Strategies

The earliest Radiophonic installation, Studio E for Paddy Kingsland, involved a Neve 8066 desk, fitted throughout with transformers, which meant there were no problems at all, even with the occasional unbalanced device. Studios C and D, again had no problems, since the Soundcraft Series 2 consoles had transformers.

Things became much more adventurous following the Soundcraft 1624 installations in Studios B and D, as these desks had unbalanced line-level connections throughout. At this point most of the other equipment had been modified to have balanced circuits, either via XLRs or PO316 jacks, meaning at least one end of nearly every circuit was balanced, which kept the worst problems at bay.

At one stage the Fairlight CMI had to be equipped with a box full of transformers. By now we began to realise that adding all these transformers, especially with multi-channel devices, was not only becoming impractical, it was also degrading the sound quality.

So began the process of reversing the process, with transformers progressively removed from devices and PO316 jacks converted back to ‘standard’ jacks. The transformers were also removed from the Workshop’s standard BBC loudspeaker amplifiers, thereby providing a significant improvement in sound quality.

There are always repercussions, of course, and a wiring fault in Maida Vale’s Studio 1 caused significant difficulties with interference in Studio B, problems that may not have shown up in a balanced installation, but that was the last such complication.

Earthing

Some advocate that earth connections should only be made at one end of an unbalanced audio circuit to avoid hum loops and other problems, but all the cables at the Worksop had the screens wired at both ends and there were no difficulties. And at no point was the safety earth removed from a piece of equipment or the internal wiring compromised to avoid such loops. Any piece of equipment with a three-core mains cable had the earth connected to both the metal chassis of the device and to the ground used for signals.

The Workshop also avoided using equipment with differential outputs that worked incorrectly into an unbalanced destination, those that sent a signal into the earth circuit. One such offender was the Akai DP3200 audio router, as used in the later 'circular' installations. These units required internal links to be changed in order for them to provide normal unbalanced outputs.

So, how did the Workshop avoid hum loops? Firstly, the incoming earthing cable was made as large as possible and multi-stranded. Secondly, the earthing to all the technical power sockets was electrically isolated from all other metalwork and any non-technical electrical installation. And thirdly, and perhaps most importantly, the mains was fed to the technical and other sockets on a radial circuit, not a ring main, as the latter can exacerbate problems with hum loops or even magnify radio frequency interference.

In the 'circular' installations the mains wiring was organised into groups fed from a 'star' point, with the audio wiring to the routers following roughly parallel lines. With the lowest possible earth resistance from each piece of equipment to the central earthing point, other paths and possible hum loops became less significant.

The Workshop was also careful to keep microphone circuits, where the phantom power was never blocked, separate from line level signals. And all audio cables were always kept as far away as possible from mains cables and other non-technical equipment.

13 September 2026

Consumer Equipment at the Workshop

Almost inevitably, the Workshop ended up using both professional and domestic equipment. The bulky BBC RP2/1 dual gramophones were soon replaced by Technics SL-1200 turntables and Surrey Electronics Stereo Disc Amplifiers, the latter providing balanced XLR outputs, all enclosed in 'speedframe' trollies, whilst cassette recorders, Sony, I recall, were installed in all of the studios, allowing copies of any work to be sent to customers.

Unfortunately the different signal levels used in professional and domestic devices sometimes posed a problem. With professional equipment, a 0 VU reading on a meter equates to +4 dBu, or a voltage of 1.228 V. In consumer equipment signal levels are measured in dBV, where 0 dBV is equal to one volt. At a reading of 0 VU most consumer devices produce only -10 dBV, equivalent to 0.316 V or -7.78 dBu. The difference in levels between professional and domestic is therefore around 12dB, a factor of four.

At the Workshop few problems were encountered with feeding studio outputs into cassette recorders, since the signals normally went directly to the recording control and overloading was avoided. The control would be set low, but this was not usually a problem, except with the Sony DTC-1000 DAT recorder where a 2.2 kΩ (kilo-ohm) resistor had to be wired across the slider of the control.

The output of a domestic cassette or DAT machine being 12 dB low had no effect the recording, but it was disconcerting to the user. So a pair of RS Components '741' cards were squeezed into each machine, one for each channel, containing a 741 IC (integrated circuit) operational amplifier, or a better equivalent, and four resistors, one of which, at around 100 Ω, was connected in the output wire or via the feedback loop, so as to prevent oscillation. Most devices had internal supplies of ±9 V to ±15 V that could also power the cards. The existing audio outputs were easily intercepted, the supply connected and the cards fitted using self-adhesive pads.

12 September 2026

The Cost of Closure

In 1979, Margaret Thatcher said ‘Any woman who understands the problems of running a home will be nearer to understanding the problems of running a country.’ This is one of those clever idealogical statements, such as ‘I think, therefore I am’, that appear to be truly perceptive on the surface, but are actually meaningless.

Thatcher believed it better to buy coal from Poland than to dig it out of the ground in Britain and that any sort of spending that didn't give an immediate return was worthless, a view followed by successive governments, both Conservative and Labour, right up to and beyond the strict austerity measures of George Osbourne.

Although Thatcher was not responsible for closing the Workshop, John Birt was made Deputy Director General of the BBC under her tenure in 1987, becoming DG in 1992 and then an advisor to Tony Blair between 2000 to 2005, thereby indicating a long philosophical thread between her and the governments that followed.

Birt introduced ‘Producer Choice’ in 1993, allowing programme creators to use outside sources, making 10,000 employees redundant in the process. It was argued, for example, that it was cheaper to buy a record off the High Street rather than get it from the BBC Record Library. I assume this ideological comment ignored the availability of the record, the cost of paying a staff member for their time and travel, the number of departments that would require the record or what would be done with the record once used.

Producer Choice initially took 481 departments, those outside the core activities of the BBC, and made them into ‘business units’. Quite how the term ‘business’ applies to departments in a public service broadcaster is difficult to comprehend, unless, of course you want to transform everything into a market economy, in which case the corporation itself should have become entirely commercial.

Inevitably, the running of any business requires the application of total costing, an entirely valid mechanism invariably used in the commercial world and pioneered by the manufacturing industries. When making a car, for example, you need to know the exact cost of materials and labour for each and every part, allowing you to calculate the entire cost of the car and the expected profits.

The costs and the profits of each department are then aggregated, with failing sections reformed or abandoned. At the BBC, the management knew which were unviable, changing them into business units, relieving themselves of any decision, and thereby blaming the staff for the closures. Very few units survived, with some elements eventually merged back into the body of the BBC.

The Radiophonic Workshop, on an expensive London site and totally costed to cover the money needed for rent, rates, utilities, staff redundancies and pensions, had no chance of survival. And capital expenditure to reduce the overheads was not made available.

The Workshop was conceived as a service department, part of a body that existed for the good of the public, not as a business. It was simply not viable as an independent organisation.

There is little doubt that the BBC was spending excessively throughout the eighties, for which only the management of the time can be blamed, and that Birt brought the corporation under better financial control, also preparing it for the expansion of digital services. But the methods used, with the suffering inflicted on staff, the damage done to morale, the chaotic breakup of BBC structures, and an increase in bureaucracy, were both clumsy and cruel.

11 September 2026

Digital Recording

On a digital recording device the BBC 'line up' level of PPM 4 corresponds to -18 dBFS, where 0 dBFS or 'decibels relative to full scale', is the absolute maximum level that can be digitally encoded.

So, any material recorded to a standard peak level of +8 dBu or PPM 6 is encoded at -10 dBFS, giving 8 db of 'headroom'. At the Workshop the peak level was often advanced to +12 dBu or PPM 7, reaching -6 dBFS, whilst many commercial music CDs were recorded even higher, almost to the point of clipping. This was only possible if a limiter was used to regulate the levels, as the distortion produced by digital clipping was utterly unacceptable.

DAT to Compact Disc Transfer

All DAT recorders operated with the usual 18 dB of headroom. To prepare an DAT recording for transfer to CD, the Workshop used a professional machine that supported recording at 44.1 kHz sampling, as domestic machines only recorded at 48 kHz. Standard 'line up' tone at 0 dBu or PPM 4 was applied to the input and the input control advanced to give an output level of +8 dBu or PPM 6.

Now, with the programme content at the input reaching a peak of +12 dBu or PPM 7, the DAT's recording meters would be at almost full deflection, although sometimes the input controls had to be 'backed off' to prevent the clipping indicators from lighting.

10 September 2026

Sound Levels

Audio recording requires the volume of sounds to be carefully controlled. Although the typical human ear discerns noises from the ‘threshold of hearing’ at a sound pressure level (SPL) of 0 dB (decibels) up to the ‘threshold of pain’ at 120 dB, an analogue tape recorder only has a range of 50 to 77 dB, meaning the signal must be adjusted to avoid hiss at low levels or distortion at high levels.

Fortunately, this marries up fairly well with the acoustic limitations of a typical room. Even so, problems with analogue recorders occur when sounds are repeatedly dubbed or mixed from different recorders, as in early projects at the Radiophonic Workshop. With some content, such as the *Doctor Who* theme, the material is so complex that noise and distortion blend into the music.

Some composers, especially Paddy Kingsland, used the distortion created by recording onto tape at very high levels to positive effect, as did the producers of many pop records of the fifties and sixties.

The BBC was conservative with levels, partly because early radio transmitters could be easily damaged by overloading. Although the SMs (Studio Managers) controlled the sound, there was always an attenuator at the input of the transmitter itself to keep it safe.

The voltage of a signal is usually measured in dBu, the u indicating that it passes to an ‘unloaded’ or high impedance input, with 0 dBu corresponding to a traditional reference of 775 mV (millivolts). A tone at 1 kHz (kilohertz) at this level is commonly used for the ‘line up’ of tape recorders, ensuring settings are correct before recording.

The VU Meter

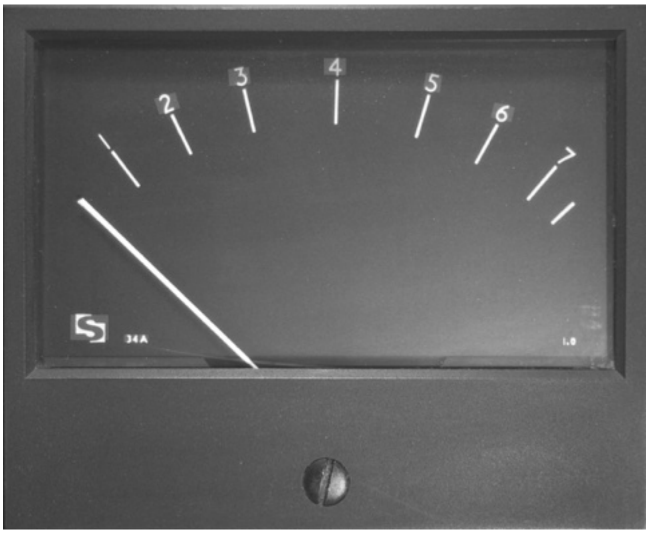
Many studios across the world have used VU (Volume Unit) meters for monitoring audio levels. Such devices measure only the average signal, any short transients being ignored by virtue of their slow mechanical response. As a result, subsequent sound recordings are usually at healthily high level, but may suffer from tape distortion.

As can see from the dial, the meter covers a range of 26dB, the range generally agreed as optimal for radio broadcasting, making it possible to hear the recorded content in most environments.

On this type of meter 0 dBu corresponds to -4 on the VU scale, even though that number is not specifically printed on the meter above, whilst 0 VU equals a voltage of +4 dBu, or 1.23 V (volts).

In normal use the meter is allowed to deflect as far to the right as possible, with few excursions into the red. Transient signals may reach more than +8 dBu or 1.95 V, but are not be seen by the user.

The Peak Programme Meter (PPM)



This meter was designed by the BBC for use in radio broadcasting. Unlike a VU meter, it instantly shows the level of most transient signals, the needle then falling back slowly to make it easier to read.

Each division on the scale corresponds to 4 dB, although earlier BBC PPMs measured 6 dB between the numbers 1 and 2, resulting in a total range of 26 dB, the same as a VU meter. Modern meters have 4 dB divisions throughout and a range of 24 dB. In normal operation, 0 dBu is PPM 4, with the signal kept between PPM 1 and PPM 6 to maintain a satisfactory range for broadcasting.

Applying 'line up' tone at 0 dBu should always cause the needle to show PPM 4, but things got complicated with stereo. The BBC decided to combine the stereo outputs of a mixing desk and then add a 3dB attenuator to create the mono output. With normal 'line up' this resulted in -3 dBu or PPM 3¼ on each stereo channel meter and 0 dBu or PPM 4 on the mono meter and with complete compatibility between between mono and stereo tape machines.

At the Workshop a recording level 4 dB higher was used to minimise noise and a 6 dB attenuator used, giving a PPM 4 'line up' on both stereo and mono meters, with staff told to peak to PPM 7 on the stereo meters and to largely ignore the mono meter.

3 September 2026

The IEC C13/C14 Mains Connector

The IEC ‘standard’ 3 pole mains connector, first introduced in 1970, is rated at 10 amps (A), the C13 being a socket, the C14 the plug. It should not be confused with the similar ‘high-temperature’ or ‘kettle’ connector standard, in which a C15 plug incorporates a protrusion to prevent it engaging with a ‘cold device’ C13 socket.

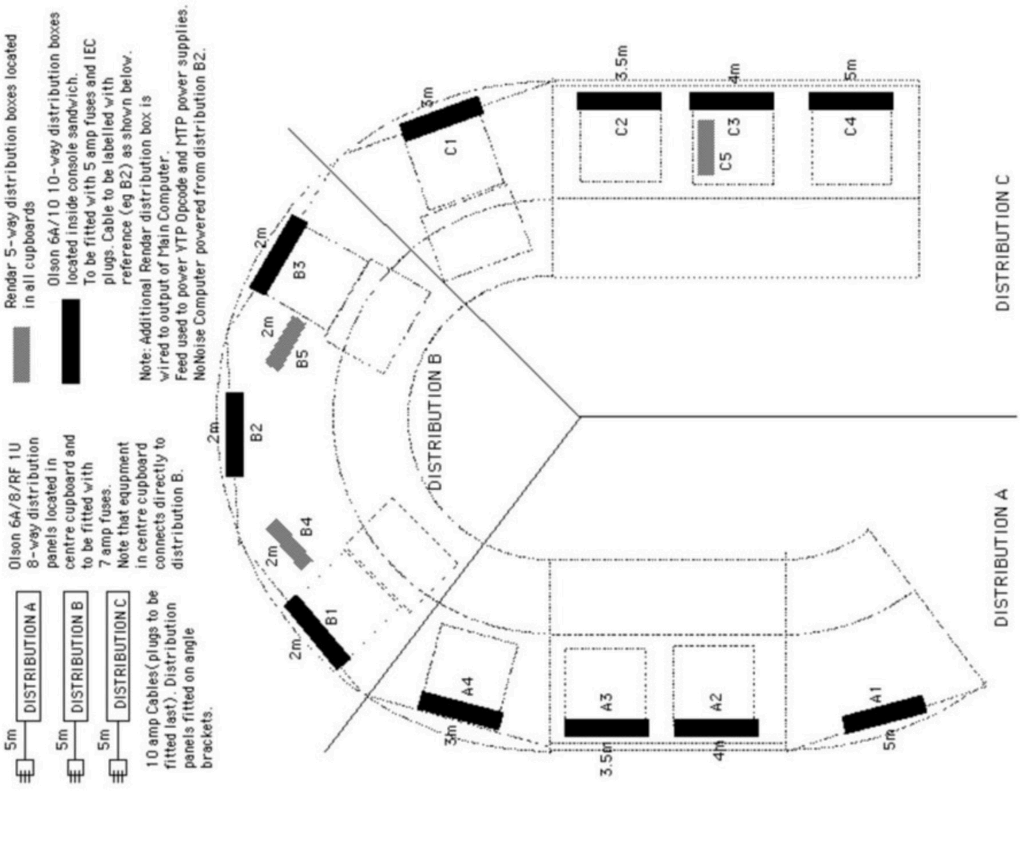
Unlike many mains connectors, the C13/C14 pairing uses a sensible size of contact pin, not as huge as a 13A plug, nor as tiny as the XLR-LNE, but probably closer in cross-section to that of an American mains plug. The connector engages without relying on the strength of the plug pins, the pins are well-protected within the shell and the design allows for shuttered sockets and optional locking connectors. It’s a shame that the IEC connector could not have been adapted for use throughout Europe as a standard wall socket.

The issue of locking mains connectors is a moot point. When IEC inlets first arrived there was concern about the plugs falling out at a crucial moment. But what is more important: that moment or avoiding someone tripping over a ‘locked’ cable, possibly damaging the wiring and posing a further danger in the future?

In this respect, standard US and European wall sockets and plugs are safer than the British type. Trip over the cable to a 13A plug and it probably won’t disengage and you will be injured. Trip over a US or European cable and the plug usually falls out.

In reality, the non-lockable IEC connectors rarely caused headaches. Later versions have a greater contact pressure, whilst various optional clips and locking connectors have also emerged.

Throughout the eighties more and more equipment arrived with C14 plugs on the rear panel, and by the time the ‘circular’ consoles arrived, the use of clumsy 13A plugs and sockets seemed inappropriate. Now, 10-way IEC power strips were available, accommodating all the devices in each rack, including low-voltage power supplies that were modified to incorporate IEC cables.



2 September 2026

Mains Connectors

The BBC has a rather chequered history when it comes to mains connectors, many of which fell at the wayside as time rolled on.

D&S Power Plugs and Sockets

In 1973 the Workshop's studios incorporated Dorman & Smith (D&S) plugs and sockets instead of 13 amp (A) plugs, so as to prevent wholesale thievery. Whether this solved the criminality is uncertain, but the D&S power strips at the Workshop were certainly unreliable. The plug was unusual in that the live 'pin' was actually a fuse, which could be unscrewed whenever a change was needed.

Swapping fuses in a 13A plug is messier, whilst 'selective fusing', choosing fuses to match each appliance, has all but disappeared, with some low-power devices often wrongly fitted with 13A fuses.

D&S connectors eventually became a headache, as every new appliance had to be fitted with a new plug. So the BBC decided, belatedly, to follow the rest of the country and use standard 13A plugs and sockets, usually of one of the types manufactured by MK.

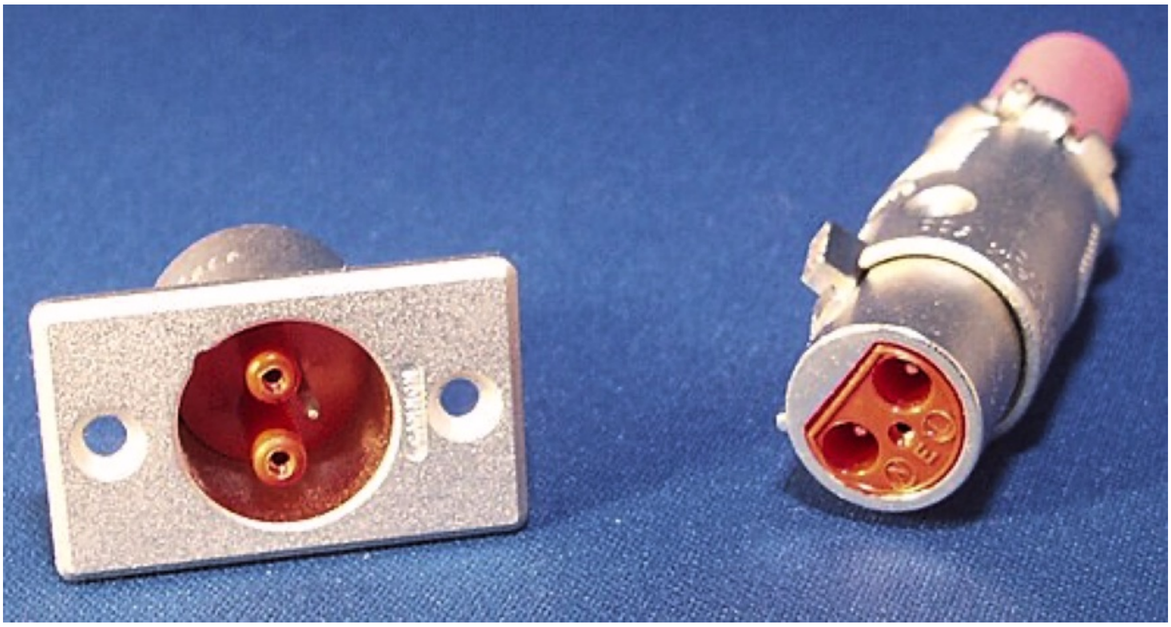
EP4 Connectors

The rather large F&E (Film & Equipment) EP4 panel connector has served many purposes over the years. The Cannon EP4-14 is the chassis mounted male version, and the EP4-12 is the female version, the latter often attached to a mains lead in earlier days at the BBC.

Female panel connectors were commonly used for cue lights, typically operating via direct current (DC) at 50 volts (V), the voltage determined by equipment common to the BBC and the GPO.

And beyond its days at the BBC, these plugs and sockets, today manufactured by Amphenol, have been used for wiring up pairs of loudspeakers. It’s very fortunate that the old and new uses of these connectors have never been combined.

XLR-LNE Connectors



Legend says these were jointly designed by the BBC and Cannon around 1968 in order to create a mains connector with the advantages of a standard XLR. What looks like a ‘plug’, on the left, has female contacts whilst the ‘socket’ has male contacts.

Oddly, the BBC decided to use the ‘socket’, with its more exposed contacts, for the mains supply and the rather better-protected ‘plug’ on the equipment, possibly because the plug required a smaller mounting hole, or perhaps because of a simple mistake. The connector is rated at 6 amps (A) and the earth contacts are designed to engage before the live and neutral pins.

A metal-shelled mains connector with a rather vicious latch does seem potentially dangerous, whilst the small pins, although gold-plated, do begin to show signs of damage if the connector is engaged with power applied. Some also consider that there is a risk of accidentally engaging a plug with standard audio XLRs, although this seems very difficult to do. The greater hazard is that a prong on the socket might inadvertently make contact with other metalwork.

This connector is no longer approved for domestic use, but even in the Workshop the latches were filed off to prevent disconnection, whilst others were replaced by modern IEC power connectors.

1 September 2026

The 3-pole XLR Connector

It would seem very simple to use a three-pole connector for audio signals, a pair of contacts for the balanced signal and one more more the screen circuit. In reality at the Workshop this almost became a nightmare.

Direction of Pins

In the commercial world XLRs are always wired with the male pins of a plug pointing in the direction of the signal, so a plug is an output, a socket an input. The BBC also used this convention for microphones, mainly because microphones always came with plugs, but with 'line level' circuits the BBC reversed the rules, so that outputs were on sockets, inputs on plugs. It may be that the corporation feared that line level circuits at an outside broadcast could somehow get shorted out and needed protection by being shrouded within a socket. This resulted in ludicrous complications when connecting commercial equipment to BBC devices.

The Workshop eventually replaced the older and larger F&E (Film & Equipment) EP3 panel connectors, formerly used for loudspeaker circuits, with male XLRs, but special female-to-female cables had to be installed, since the BBC amplifiers also had male connectors.

The Workshop eventually adopted commercial practice, including reversing back the connectors on Studer A80 tape machines.

Polarity

The name XLR comes from the codes originally used by Cannon Electric when the connector first appeared, with X standing for the X-series, L for locking and R for the rubber around the female contacts. Today, the name is a handy acronym for the pin connections: X (screen) = 1, L (line) = 2, R (return) = 3. The wire called 'line' is often known as 'hot' and the 'return' as 'cold' Unfortunately this 'standard' was sent awry by audio engineers in the USA who decided pin 3 should be 'hot' and pin 2 'cold'. Worse still, some UK manufacturers, including Soundcraft, who provided several mixers for the Workshop, decided to follow suit.

With all circuits balanced, this reversal isn't a disaster: the connection still works, but a 'blowing' sound on a microphone may end up as a 'sucking' sound on the loudspeaker, which gives a entirely different impact. Of course, this may nor happen if the wires get swapped again at another connection to the mixer. Fortunately, all Soundcraft mixers had a 'phase reverse' switch on each channel, allowing any reversal anomalies to be corrected.

The real problem came with equipment that had unbalanced circuits connected via XLRs, meaning that any unbalanced device with 'pin 3 hot' would fail to work with another that was 'pin 2 hot'. For a while, some equipment, such as the Fairlight CMI, were fitted with transformers, which fixed the problem, but the use of transformers always degraded sound quality and they were subsequently removed wherever possible, including from loudspeaker amplifiers. The Workshop operated with the 'pin 3 hot' convention for a time, but with newer installations it returned to the now international standard of 'pin 2 hot'.

The Workshop also had some unusual cables for conveying MIDI over XLRS, with DIN plug pins 4 and 5 connected to XLR pins 2 and 3 respectively, along with connected screens. This convention was based on pin 4, normally pulled up to +5 volts, being effectively the 'hot' connection, although the more modern standard is to connect the two data pins the other way round. In any event, all the cables the cables must be wired the same way. Also, such cables must not be connected to XLR microphone cables carrying +48 volts of phantom power, as this can damage the circuitry.

10 August 2026

The Double-Ender

For the first twenty years of its history most audio devices at the Radiophonic Workshop were connected by cords known as double-enders. Originating from the General Post Office (GPO) in the earlier years of the century, and used in many manual telephone systems, it featured a Post Office 316 jack plug at both ends, with separate wires to the tip, ring and sleeve (TRS), with the 'hot' circuit was on the tip, the 'cold' on the ring and the sleeve grounded.

The Post Office described it as a 'B-gauge' plug, having a ¼-inch diameter. Unlike a modern plug, it has a tip smaller than the ring or sleeve, thereby preventing the plug shorting out the signal wires on insertion, which could have caused problems on a switchboard.

Different colours could be used for the body of the plug, but at the BBC the plugs were nearly always a shade of browny-red known as cerise. The usual cords were screened, this feature being indicated by an exterior blue colour, but other cord colours could be found, such as black, red or yellow, the latter for a phase reversal cord.

In terms of reliability these connectors were incredibly robust. The sockets exerted a huge amount of pressure on the un-plated brass plugs, thereby providing a self-cleaning action, especially necessary for a telephone exchange.

Unfortunately, they weren't suited to being left in-situ for long periods of time, as oxidation would build up, or when used with more modern 'compatible' plastic jacks that had gold-plated contacts that exerted a low pressure on the plug. Some engineers advocated polishing the plugs, but that only made the metal surface smoother and even more prone to oxidation problems.

Although the connector allowed creators of sound and music to connect devices easily on a ad hoc basis, it would sometimes be impossible to work out what had been connected to what, ending up with a vast ball of double-enders that needed to be disentangled.

The Workshop eventually switched over to using XLR connectors for connecting equipment, but in later years began following the commercial practice of also using standard jack plugs and other connectors. The Workshop even used standard jack plugs in jackfields designed for the PO316. Bad practice, perhaps, in terms of engineering ideology, but no problems were encountered.

Today, plated versions of the 316 are still available, but are rarely used on modern equipment.