FEATURE - PART 2

(R)evolution of Portable Audio: Things Getting Reel

The secret German invention of polyvinyl chloride magnetic tape and a surprise accidental discovery led to an entertainment revolution that lasted more than 50 years. Darren Yates *writes.*

Above: The Magnetophon tape recorder combined AC-bias recording with PVC magnetic tape during WWII (Image credit: George Shuklin, CC-BY-SA 1.0).

It's a sad but inevitable fact that wars bring inventions and world-changing inventions, like the cavity magnetron, weren't just limited to the Allies during World War II. For nearly 40 years, machines had been magnetically recording sound onto compact spools of very thin steel wire. These 'wire recorders' were still to have their brief heyday in the U.S. in the late-1940s and early-1950s. But in 1941, German engineers had already invented and discovered a technology combination that would revolutionise the entertainment industry around the world during the latter half of the 20th century.

The 1935 Berlin Radio Show

The idea of recording high-quality audio isn't new (just ask any podcaster), but neither are the tenants that determine recorded quality. You need a device capable of capturing sound but generates no background-noise of its own (called 'high signal-to-noise ratio'); you need the ability to capture frequencies right across the audio spectrum ('wide frequency response'); and you need a device with high linearity to capture those frequencies accurately ('low total harmonic distortion').

In 1935, the new Magnetophon tape recorder from German engineering giant AEG (Allgemeine Elektricitats-Gesellschaft) greeted the Berlin Radio Show with its new PVC (polyvinyl chloride) magnetic tape from German chemical group IG Farben/BASF. Spinning with a high one-metre-per-second tape-speed, the Magnetophon could capture much of the audio spectrum, but early recordings were said to have noticeable distortion and background noise. Over the next four years, incremental improvements were made by changing the tape's chemical formula and applying a DC-voltage to the recording process. But the greatest improvement would come largely by accident.

Below: The initial 1958 'black box' wire recorder featured three separate reels (Image credit: John Broomfield, Museums Victoria, CC-BY-4.0)

A chance discovery

Early tape recorders worked by applying an audio signal to a wire coil attached to a special alloy frame, collectively called a 'recording head'. The audio signal causes the wire coil to generate a magnetic field that changes with the signal. The head also has a tiny physical gap – this allows those field changes to be magnetically imprinted onto the recording tape as it passes across the head.

During 1941, two engineers at the German national broadcaster RRG received a Magnetophon recorder with a work-order to fix a fault. What they discovered wasn't a fault at all, but a chance random effect that greatly increased the audio quality. Magnetic tape is inherently non-linear, meaning that it doesn't record signals proportionally – simply making the audio signal louder on the tape by increasing its amplification just adds greater

imperfections or 'distortion' to the quality.

It turned out that the 'faulty' recorder's built-in amplifier was resonating or 'oscillating' at an ultrasonic frequency beyond human hearing. On top of that, the audio signal was being accidentally mixed in at a much lower level than this ultrasonic signal onto the tape (a process today called 'AC-biasing'). This effectively moved the audio into a more linear magnetic region of the tape, greatly reducing the distortion and for the first time, people heard the quality of magnetic tape recording.

By 1943, the tide was beginning to turn against the German forces, but continued German research resulted in the first stereo tape recorder. There is an incredible stereo recording of Beethoven's Allegro from Concerto No. 5, reportedly recorded in Berlin in 1944 on a stereo Magnetophon machine (**https://youtu.be/EY7lvuVjjX4**). Scroll to 5mins36secs and you can hear air-raid artillery low in the right channel during quieter passages. Just extraordinary (and the audio quality is superb!).

Above: Wire recorders were the first 'electronic memory' to record audio (Image credit: Catalogo Collezioni, CC-BY-SA 4.0)

Battle Broadcasting

Newsreels during WWII brought the (albeit censored) vision of war to movie theatres around the world (legendary Australian war-correspondent Damien Parer received an Academy Award for his memorable 'Kokoda Front Line' footage). But until late-1943, much footage was largely vision-only.

One of the very first portable audio recorders was developed as an experiment and used in arguably the most trying of conditions. Two technical-sergeants of the U.S. Marine Corps, Fred Welker and Keene Hepburn, took a wire recorder, stripped out of it everything it didn't need and carried it into battle, capturing the real sounds of war. Today, the U.S. Library of Congress has this audio history of the Battle of the Marshall Islands from 1 February 1944 online (**https://tinyurl.com/apcrecorder**). The Marine Corps continued making recordings until the end of the war, many of which are now contained in the U.S. Library of Congress.

To the victors...

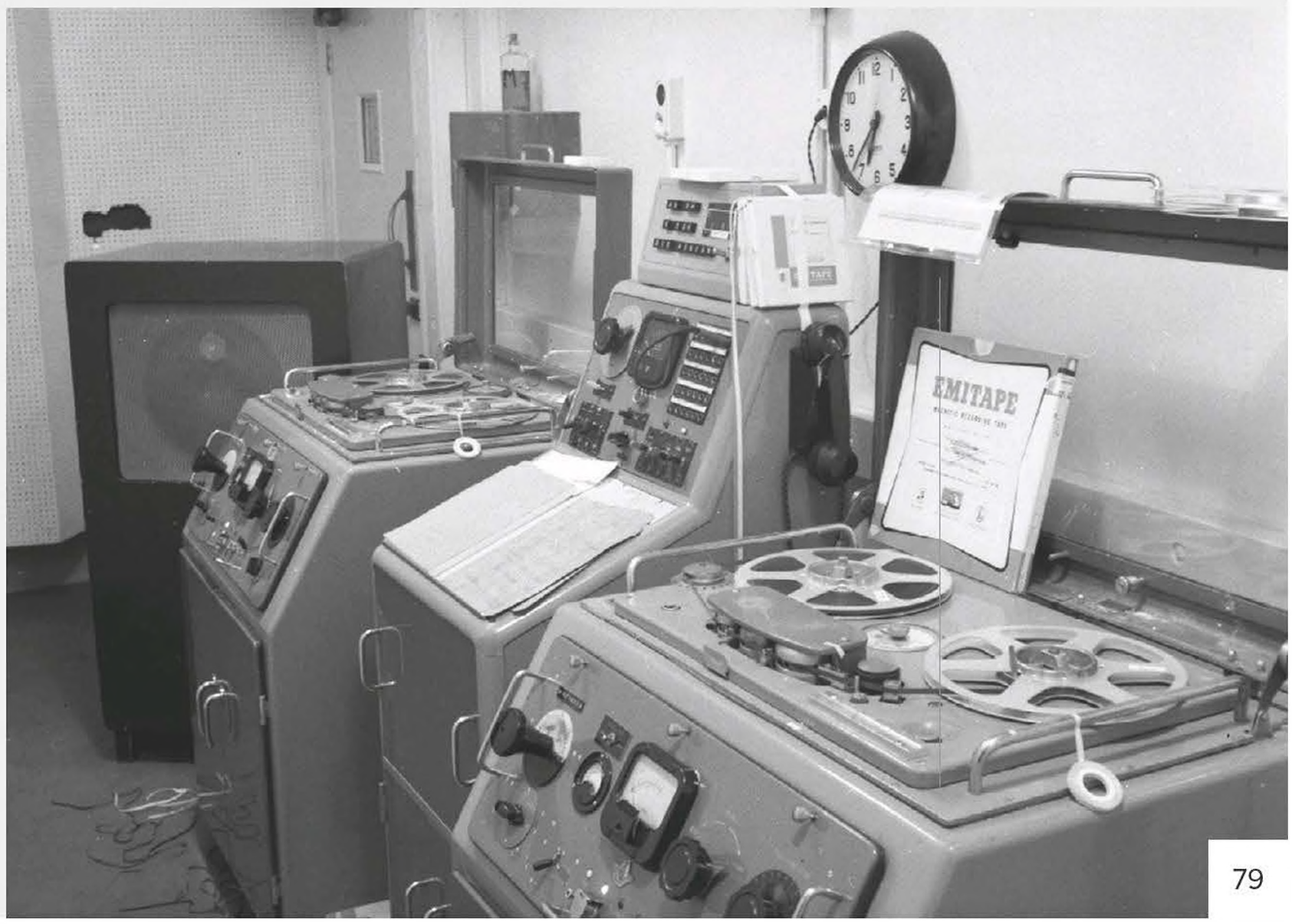
Meanwhile, the Allies knew about the German Magnetophon recorders before the war, but apparently had no idea about AC-biasing and PVC tape, only to discover them when they overran German forces during late-1944/early-1945. What's more, they didn't seem all that interested and it was left to U.S. army officer Jack Mullin, who legally acquired two Magnetophon recorders, 50 reels of tape and took them back with him to the 'States.

Mullin had the skill to modify and improve the machines further, but not the backing to turn them into a commercial reality. Enter singer/actor Bing Crosby. Tired of performing live radio shows and looking for a higher-quality option than the standard transcription record discs of the day, Crosby heard Mullin's machines via a 'test-taping' of one of his (Crosby's) shows. The results were so good, Crosby hired him on the spot and signed Ampex Corporation to make machines with Mullin's help. By 1948, the Ampex 200A recorder was winning over entertainment executives across the country.

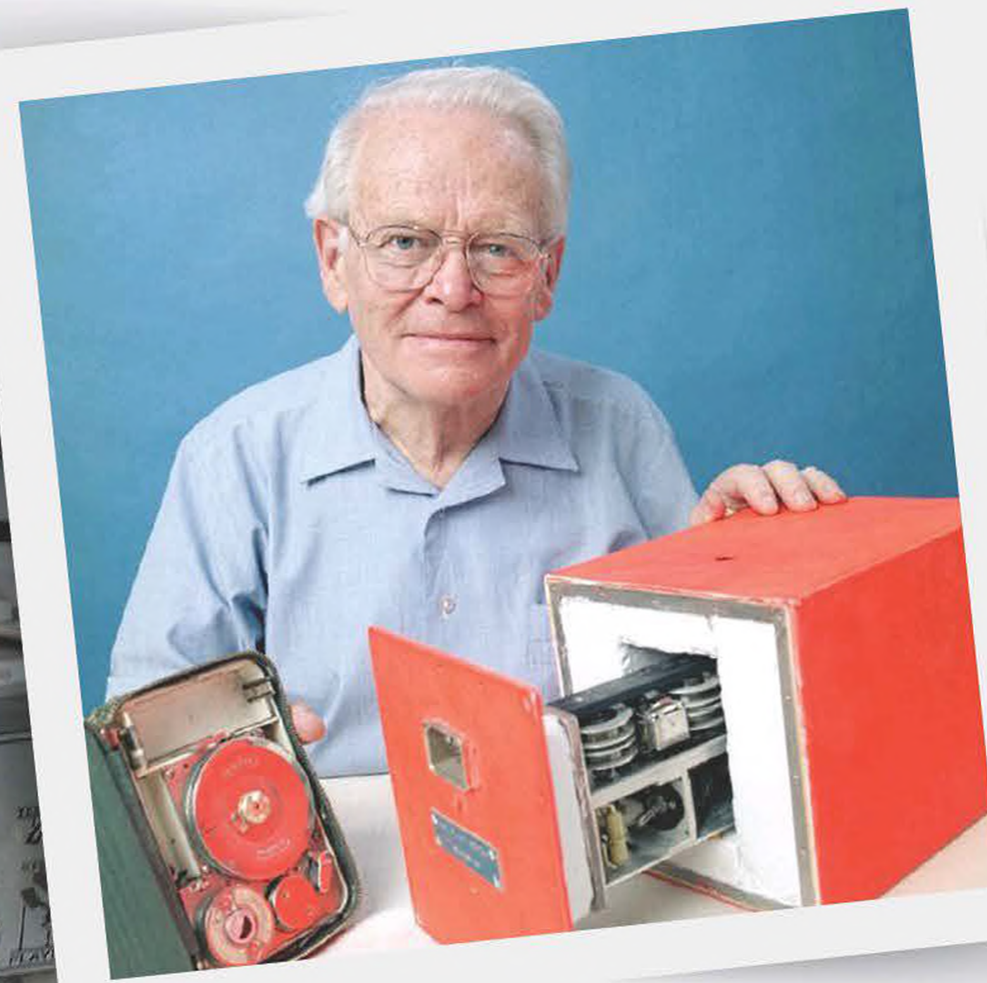
Enter the transistor

Last time, we saw how the size of 1940s radio-valves/vacuum tubes limited the ability of radio designers to shrink their designs. Tape recorders were considerably more complex and as a result, early units, like the Ampex 200A and 300 models, plus the British EMI BTR2s in England, were built in large steel console units to house the valve circuitry and motors.

But audio recording would soon benefit from another new technology beginning to hit its straps – the transistor. Despite being invented in 1947, it took time to develop the manufacturing



Below: Music Recording giant EMI famously made its own tape recorders, like these BTR2 machines at the BBC, 1961 (Image credit: RFWilmut, CC-BY-SA 3.0).



Above: The Nagra IV-S, arguably the best portable reel-to-reel recorder ever made… (Image credit: Hens Zimmerman, Zeist, The Netherlands, CC-BY-2.0).

Above: The Australian inventor of the aircraft 'black box' flight recorder, Dr. David Warren (Image credit: Museums Victoria, CC-BY-4.0).

techniques to make transistors in quantity. However – and this is why transistors were so revolutionary – as the 1950s progressed, the size of tape recorders continued to shrink and by the end of the decade, some of the first affordable, transistorised, portable tape recorders were hitting the market.

Developed by the German 'Trix' toy company in 1958, the 'phonotrix 1' was also thought to be one of the first tape recorders used by secret agents during the Cold War.

It's a compact recorder operated by four 'D'-size batteries, with a separate speaker unit. The tape reels are a tiny 7.5cm (three-inch) and at a speed of 3.75-inches (9.5cm) per second, give you approximately 15-20 minutes of recording time.It's also a 'half-track' recorder, meaning that once the tape has been recorded, you can 'turn over' the reels and record another 20 minutes on the other side of the tape.

The 'phonotrix 2' appeared the following year with recorder and speaker combined. Trix also manufactured recorders under the 'Clarion' brand and a number of these units made their way out to Australia.

The original model had a speed control that allowed spies to tap out their Morse code messages onto tape, but play them back at higher speed when transmitting them via radio. Speeding up the transmission would make it harder for any government listening posts to find the radio source.

Below: Ampex introduced the Model 300 tape recorder in 1949 (Image credit: Cliff, CC-BY-2.0).

Australian-made

Much of the initial technical development for tape recording originated in Europe and the U.S., but we also designed and made our own tape recorders here in Australia. Arguably the most famous of these were made by Byer, a small manufacturer in South Melbourne.

The most well-known examples, the Byer 66 and 77 models, were as tough as teak – over 200 Byer 77s were brought in by the-then Australian Broadcasting Commission (now Corporation, ABC) for the 1956 Melbourne Olympics. Both units were considered portable, with the Byer 66 built into a ruggedized suitcase that could be carried between locations. The original Byer 55, launched in 1953, is believed to be the first Australian-designed tape recorder, but sadly, few examples remain today.

By 1958, another iconic Australian audio company, Rola, had taken over the business and Max Byer moved to Holbrook, in southern NSW, opening a motel. The 'Byer Fountain Motor Inn' still stands today. However, Rola would be taken over by Plessey Electronics during the 1960s and Plessey by Philips in the 1970s, as the Australian electronics industry consolidated.

Pop-culture icon

The decade between 1955 and 1965 was arguably reel-to-reel tape-recording's pop-culture moment – new magazines dedicated to tape recorders hit the newsstands and recorders were the 'PCs' of the era.

Back then, you could buy tape recorder chassis parts at wholesale, build your own electronics, put the lot into your own casework and create a brand. Many did – and many disappeared almost as quickly. However, by the early-1960s, a new wave of Japanese brands such as Sony, Sanyo and National (Panasonic) began launching compact portable tape recorders, thanks to the now fast-improving transistor market.

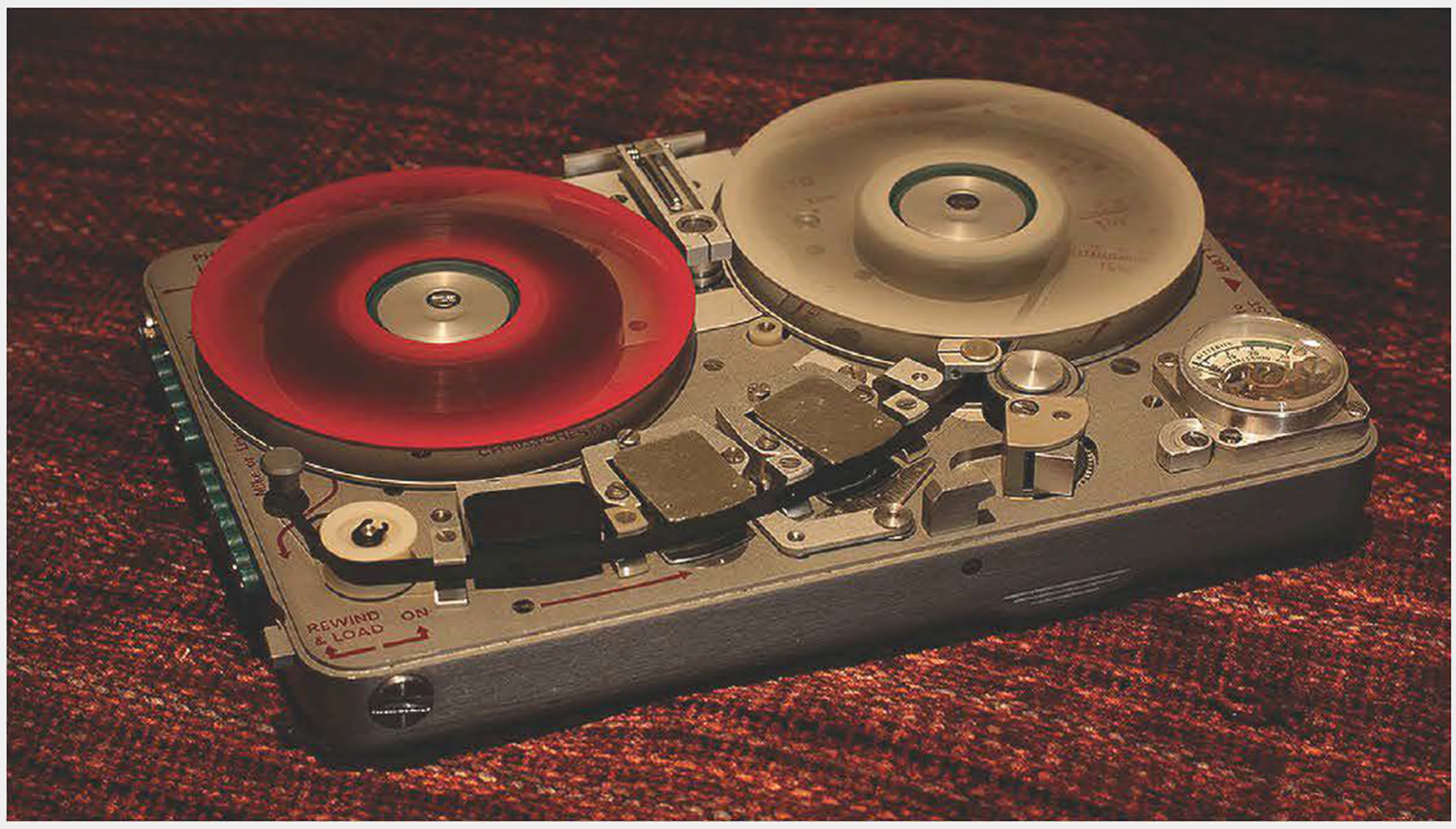
These little wonders captured the imagination and began turning up in movies and TV shows, most famously the 'spy' genre – and James Bond movies in particular (look out for the very rare Stuzzi 304B in 'From Russia With Love'). They also stole the show in each 'Mission: Impossible' TV episode.

High-Fidelity

The 1960s was also the beginning of the 'hi-fi' era, where sound quality became a much sought-after commodity, pushed along by the arrival of micro-groove long-play ('LP') stereo records and higher-quality speaker systems. Many home recordists soon realised that recording their LPs onto tape would allow them to endless play the tape, whilst keeping the LPs in pristine condition. However, analog copying was a slow and lossy system, where each copy of a copy would deteriorate the original sound. It wouldn't be until the combination of digital recording and the internet in the late-1990s that audio recording technology would give music executives nightmares.

If there's one brand that represents the 'Rolls-Royce' of portable audio recording during the 1950s-1980s reel-to-reel era, it'd be Swiss brand, Nagra. If a Swiss watchmaker decided to build a portable tape recorder, you'd still struggle to get anything better than the Nagra range. In fact, the first model, the Nagra I, was hand-made by founder Stefan Kudelski, then an electrical engineering student, when he was just 22-years-old in 1951 and featured a hand-wound clockwork motor.

New and improved models continued to appear and Nagra recorders gained a reputation for their Swiss-precision, earning them favour in Hollywood. To-date, Nagra has received two Academy Awards for its recorders. Vintage 1970s/80s Nagra tape recorders sell for a motza today as a result.



Above: The Nagra SNS, the ultimate compact spy recorder (Image credit: Hiendaudio, CC-BY-SA 3.0).

Storing computer code

By 1969, even the concept of storing computer data onto tape-reels had entered the mainstream and famously featured in the movie, 'The Italian Job', starring Michael Caine. However, the idea of storing computer data onto tape actually dates back to as early as 1951, when the UNIVAC I (Universal Automatic Computer I), a valve-powered mainframe computer was given a storage unit called the UNISERVO. In this case, the tape was metal (nickel-plated phosphor-bronze) and reportedly ripped through the machine at the speed of 2.54 metres per second or 9.1km/h.

Many of us who grew up in the 1970s and 80s will remember using a different tape format to store programs from our 'home computers' – but we'll save this for next time.

Traveling far – by tape

Apart from computer storage, there was another more serious, but equally important application for portable audio recorders. During the early-1950s, the world watched in horror as a number of De Havilland Comet passenger aircraft crashed from the sky. The remaining Comets were grounded, while experts from Australia's Department of Civil Aviation and the Aeronautical Research Laboratories met to try and discover the cause. It was Australian ARL scientist, Dr. David Warren, who, struck by the basic lack of available data, developed the flight-deck/cockpit voice recorder. The initial versions were wire recorders, later replaced by magnetic tape and finally by digital recording.

The other thing tape recorders invented was the 'letter-tape' – instead of writing letters, you could now record the family sending greetings to loved ones overseas, send the tape in the post and a few weeks later, your extended family could hear you. Given overseas phone calls, let alone plane travel, were still play-things of the 1960s' rich and famous, a small three-inch reel could give as much as 40 minute of family news. What's more, you could play it back whenever you wanted – better than a one-time phone call. It might seem quaint today, but at the time, this ability for anyone to capture sound for posterity really was revolutionary.

Above: The Phonotrix 2 was the bigger brother to the smaller unit used by spies during the Cold War (Image credit: Joe Haupt, CC-BY-SA 2.0).

Change in the wind

Nevertheless, even while tape recording was hitting its stride in the early-1960s, a monumental change was on the horizon. The required process of 'lacing up' a tape through a tape recorder was thought to be both too complex and a time-waster for many consumers. Why not have a cartridge-style tape mechanism the user just loads into a machine? Next time, we look back at attempts to create a 'compact' tape format, culminating in one that would revolutionise portable audio and drive popular culture for nearly 40 years. ■