Beginning Electronic Music

Tristram Cary - Part 1

Published by Stephen Jones

The purpose of this extended note on Tristram Cary is to provide a context within which to introduce several electronic music instruments within the collection of the Powerhouse Museum. These will include two pre-synthesiser devices, early EMS synthesisers and other custom built objects that are now part of the museum's collection.

Tristram Cary, an Adelaide based electronic and computer music composer, was a son of the author Joyce Cary, grew up in a musical family and learned to play the piano from the age of five. He entered University (Oxford) in 1943 to study Classics but kept up his interest in music. This was during the Second World War, so on turning eighteen that year he volunteered for the Royal Navy. Having had teenage experience in building radios and other bits and pieces, he gained a post as a wireless mechanic and studied electronics. He was appointed a Radar Officer in 1944, installing and calibrating radar sets on board ship.

During this period he continued his interest in music and began to teach himself musical theory and composition. He heard of the development of tape recording while in the Navy and he realised that he could edit and make musical works by cutting up the tape with a razor blade and re-splicing it. As he later said:

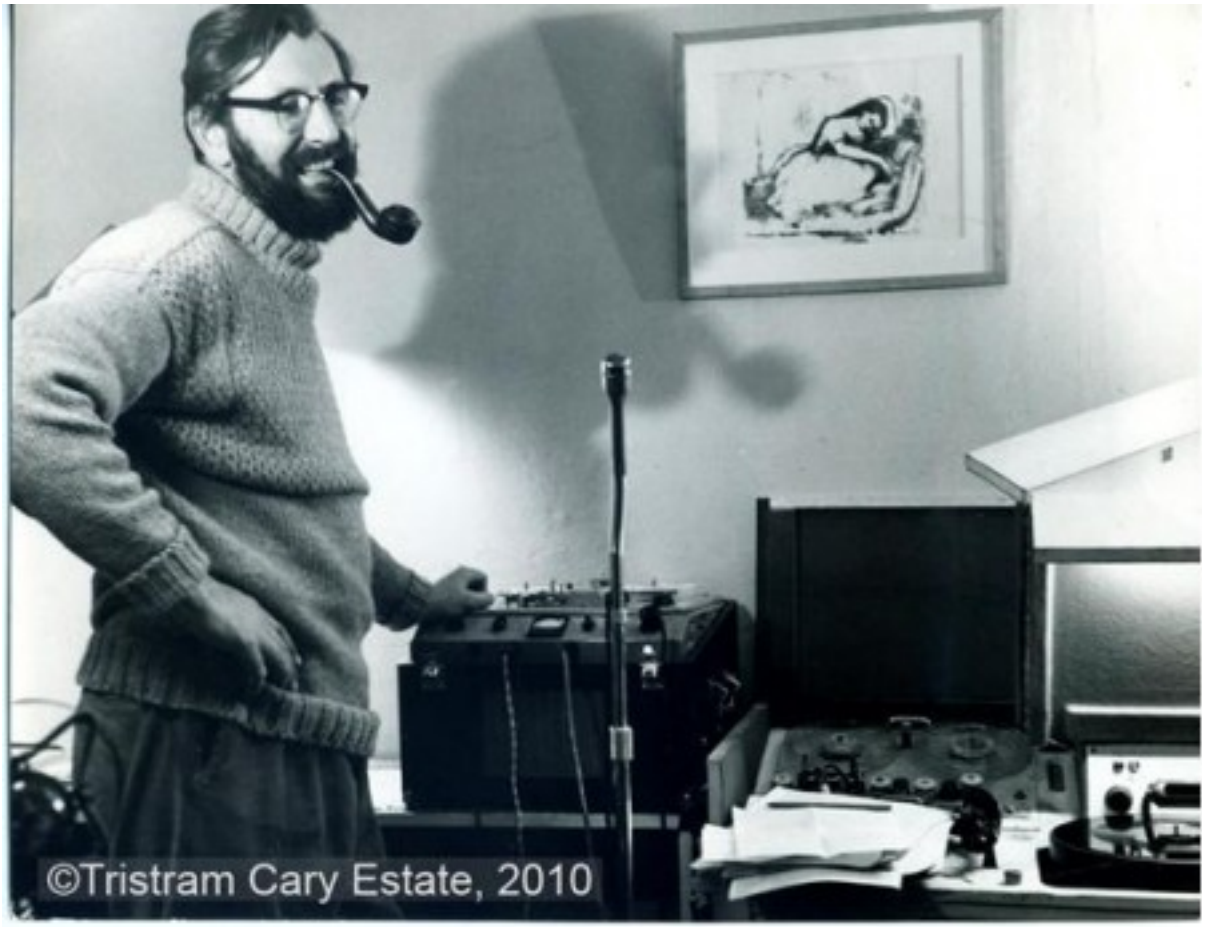
It occurred to me that ... here was a chance to have a new sort of music altogether. The editing capacity meant that you could cut sounds together that were not normally together.[1]

He was de-mobilised from the Royal Navy in late 1946 and by then, effectively, a qualified electronics engineer he turned these skills acquired as a radar operator to making musical devices. He recognised that he could use [his] skills to make [his] own studio, and design [his] own gear, and so for very little money there was a mass of surplus stuff. There was the junk of three armies: the American, the German and the British Army, was in the London junk shops and you could go around, pick up gear cheap, sometimes absolutely brand new still in the original case. Probably designed for another purpose, but if you knew what you were doing, you could make it do something different.[2]

At the end of his time in the Navy he finished his degree at Oxford and then enrolled to study music at Trinity College, London. His background in electronics meant that he understood the theory that any sound could be constructed through the summation of a suitable ensemble of sine waves.

With the end of the war tape recorders began to become available in the UK but were the sort of things that only the BBC could afford so Cary used his skills to try to build a recording device disc from a turntable and record cutting head, which used a weight to turn the disc at a constant speed, but it didn't work very well.[3]

His original attempt to build a disc cutter led him to later purchase a 78rpm disc lathe, with which he began making his own version of musique concrète, recording sounds he wanted to use, manipulating them through amplification and cutting them into his instrumental recordings, only discovering the French work of Pierre Schaeffer and his colleagues later.[4]



Cary in his Earl's Court living room/studio. The tape recorder he is resting his left hand on (a TR51) can still be seen in the Fressingfield studio, the gear to the right of the picture is another tape recorder (the Bradmatic) and to the right (half cut off) is the disc-cutting lathe. The picture on the wall behind Cary is by William Thompson, a friend of Cary's.

In the period of the 1950s electronic music had little presence but there were a few people who were doing things that made it possible to begin to think about it. Schaeffer, in France, had been using tape recorders to capture sounds from the urban environment to cut and splice into complex musical adventures that brought industrial sound to the radio and the concert hall. The radio station Westdeutscher Rundfunk (WDR), in Cologne, Germany, had assembled an electronic music studio using surplus radio test equipment.

Their view was implacably opposed to the French process of manipulating sampled sounds. For the Germans the idea was to produce sound purely electronically using only summations of sine waves. The master of this process was Stockhausen but even he relented by the 1960s when he produced Gesang der Junglinge.

Cary began to experiment with electronic sound in 1947, building variable-resistance tuned oscillators similar to those he used in the Navy and a keyboard with electrical contacts from an old Harmonium.[5] He was mainly writing instrumental music at this point and didn't produce fully electronic music until well after he moved to Nevern Rd, Earl's Court (in London) in 1951, where he built a new studio based on disc-cutting machines. The Bradmatic tape recorder became available in 1952 and Cary bought one with which he began composing electro-acoustic and orchestral music for radio and film. His first properly electronic work was for the radio play The Japanese Fishermen (1955), which required special sounds to represent the sea, the fishermen rowing and the mystery of their illnesses, the result of radiation from American nuclear bomb tests in the Pacific.[6]

His first great success was the instrumental music score for the film The Ladykillers (1955) starring Alec Guinness and Peter Sellers. However his primary source for sound was the recording of everyday domestic sounds manipulated with the disc cutters and tape recorder. He continued to write music for radio, film and television producing the sound for Richard Williams' The Little Island which won the best experimental film at the 1958 Venice Film Festival [7], and the radio piece The Ballad of Peckham Rye (based on the novel by Muriel Spark and directed by Christopher Holme) for which he won the Premio Italia prize at the Concorso Internazionale Per Opere Radiofoniche E Televisive, Verona 1962.

All of these works consisted in a mixture of instrumental sounds, musique concrète and electronically generated sounds.

Premio Italia prize for Cary's music for the Ballade of Peckham Rye (1962). Collection: Powerhouse Museum [2009/83/18

[1] David Ellis, "Music pioneer celebrates milestone", Lumen, The University of Adelaide Magazine, winter, 2005, http://www.adelaide.edu.au/lumen/issues/5381/ news5593.html

[2] Cary quoted in Andrew Ford, "Interview with Tristram Cary," for the ABC Music Show. Transcript available at http://www.abc.net.au/rn/musicshow/stories/2006/17/18642.htm

[3] Kaye R. Fitton, Tristram Cary: Pioneer of Electronic Music in England, Masters of Music Thesis, Adelaide: University of Adelaide, 1983 (University of Adelaide Library – AV 09MU.M, F547 c.2/1-3).

[4] Andrew Ford, "Interview with Tristram Cary," for the ABC Music Show.

[5] Fitton, Tristram Cary: Pioneer of Electronic Music in England. In the Ford interview he says 1949, but the Fitton thesis has a cartoon drawn by a friend of his, showing the keyboard and other bits of valve electronics, which is dated 1947.

[6] The Japanese Fishermen (BBC Radio, 1955, prod: Terence Tiller) on the CD Soundings. [Tall Poppies, TP139]

Beginning Electronic Music

Tristram Cary - Part 2

Published by Stephen Jones

By 1962 Cary was not the only composer including electronic and concrete sounds in their work. In 1957 Daphne Oram and Desmond Briscoe began developing what they called “Radiophonic” sound for broadcasts of drama from the BBC Third Programme. Their works included Samuel Beckett’s All that Fall and Giles Cooper’s The Disagreeable Oyster (both 1957).[1] Then in 1958 the BBC established their Radiophonic Workshop at Maida Vale, London, where the main technique at this stage was tape manipulation and editing. Oram left the BBC in 1959 to set up her own studio and develop a synthesiser that used hand-drawn waveforms on film to control the oscillators.[2] The BBC proved to be one of Cary’s main employers and he produced several commissions a year for them. From 1960 he contributed to several BBC educational programmes on contemporary music for which the Radiophonic Workshop produced some of the music.

In 1962 Delia Derbyshire joined the BBC. About this time there were Ferrograph tape recorders, a WWII period outside-broadcast (O/B) sound mixer, a reverberation chamber and a wobbulator which (although originally mechanically swept) consisted in an oscillator swept by a second oscillator. It was an engineering test instrument but here will be the beginnings of voltage control. Another batch of tape recorders (now Philips machines) with editing blocks and remote start controls were added about this time. There was also a set of 12 oscillators, each of which could be independently tuned, and whose outputs were switched by a 12 key “keying unit” that fed the selected oscillator to a type of valve amplifier known as a “variable-mu pentode” in which the gain (amplification) of the valve was controlled by an external voltage source which had adjustable attack and decay timing and thus functioned as a voltage controlled amplifier (VCA).[3] Cary built himself a Transient Waveform Modifier which was a set of four amplifiers based on similar devices, [PHM: 2009/83/2].

Tristram Cary in the Fressingfield studio, operating his double ring modulator.

It was Derbyshire who realised Ron Grainer's original visual score for the title music for Dr Who, developing the sounds that so many of us grew up with, and thereby introducing electronic music to the generation for whom it was all so influential. Cary's role in Dr Who was in making some of the incidental music for several early episodes, including the introduction of the Daleks. The Dalek's voices were made by Brian Hodgson using a ring modulator built from a pair of transformers with a ring of four diodes between them.

Also in 1962 Cary decided to move out of London. He bought a farmhouse, "Wood Farm", in Suffolk, where he stayed until 1974, and around mid-1963 re-established his Fressingfield studio in an out-building. He abandoned the disc cutter for more tape-recorders and assembled the studio from devices that he eventually built into a wall of electronics in racks and a minimal patching and switched selection control panel with a six channel mixer. There he built several pieces of equipment that the Powerhouse Museum now has in its collection. These are a voltage controlled oscillator and an envelope shaper, and will be discussed in following blogs.`

The main oscillators, control panel, and tape-recorders in Cary's Fressingfield studio.

Around this time (c.1960) Peter Zinovieff, the son of Russian émigrés to Britain, and whose hobby was electronic music, began to buy waveform generators, noise generators and other stuff from the war surplus electronics stores in London. He also bought a couple of tape-recorders and started making electronic sound with this gear, building a crude sequencer using telephone relays.[4] He had met Daphne Oram and she taught him how to assemble sounds into music. He later worked with Delia Derbyshire and Brian Hodgson of the Radiophonic Workshop forming the group Unit Delta Plus who played live electronic music at the Roundhouse in London, among other activities.

Around 1965-6 Zinovieff met David Cockerell an electronic designer who had already designed a ring modulator and a voltage controlled oscillator.[5] In 1967 Zinovieff bought a pair of DEC PDP8s which he intended to use to make computer music. As the PDP8 was not in itself powerful enough to do direct tonal synthesis it was coupled to a variety of analogue devices (VCOs, VCFs, etc) which could produce tones, thus creating a hybrid system in which the computers generated control voltages for the analogue components.[6] With Cockerell's technical support, Zinovieff began to assemble the PDP8s into a computer-driven sequencer to control the proposed system for the production of sampled sound (an idea that came from the ideas of musique concrete) which was to consist in a block of filters and oscillators. Cockerell took charge of the engineering in Zinovieff's studio in 1968. Meanwhile in 1967 Zinovieff met Tristram Cary and in 1968 the three of them set up Electronic Music

Studios (EMS) to run the PDP8 lab and build the instruments necessary with which to compose electronic music.

Cary had been appointed director of the Electronic Music Studio at the Royal College of music in 1967 and had a studio built, which was ready to use in September 1968. [7] Cary's students at the RCM included Laurence Casserly and Howard Davidson. Earlier that year (January 15, 1968) Cary and Zinovieff produced what may have been the first electronic music concert in Britain.[8] As well as works by Cary and Zinovieff it included compositions by Ernest Berk, Delia Derbyshire, Daphne Oram and Ivor Walsworth, George Newson, Jacob Meyerowitz and Alan Sutcliffe.[9] Sutcliffe had written a stochastic music composition on an ICL computer and recorded it to paper-tape, which he and Zinovieff then realised as ZASP on Zinovieff's PDP8 in this concert. [10]

A little earlier Robert Moog had proposed the use of voltage control in a paper to the 1965 Audio Engineering Society (AES) convention in New York.[11] It wasn't actually a new idea, for example a wobulator or sweep frequency generator could be built using voltage control, but Moog used an exponential control ratio and this meant that a change of one volt in control voltage produced an exponential change in the frequency and thus you had a one volt per octave control system. From there, a keyboard controlling the frequency of the oscillator was a simple thing. Not that many of the early electronic composers were at all interested in using keyboards. But that option did make Moog's synthesisers trendy in popular music.

[1] Darren Giddings, "Concrete Mixers, The story of the BBC Radiophonic Workshop", 2003. [http://www.mb21.co.uk/ether.net/radiophonics/mixers.shtml]. See also Wikipedia on Desmond Briscoe [http://en.wikipedia.org/wiki/Desmond_Briscoe] and Wikipedia on the Radiophonic Workshop [http://en.wikipedia.org/wiki/ BBC_Radiophonic_Workshop]

[2] This is described in Steve Marshall, "Graham Wrench: The Story Of Daphne Oram's Optical Synthesizer," Sound On Sound, February, 2009. Available at http:// www.soundonsound.com/sos/feb09/articles/oramics.htm

[3] See "Derbyshire Electronic Music Pioneer" http://www.delia-derbyshire.org/ index.php , and Ray White (2004). BBC Radiophonic Workshop: An Engineering Perspective, chapter 2 [http://whitefiles.org/rws/r02.htm]

[4] Trevor Pinch and Frank Trocco, Analog Days: The invention and impact of the Moog synthesizer, Cambridge, Mass.: Harvard University Press, 2002, pp. 280 .

[5] Ibid., p.285.

[6] Tristram Cary, Illustrated Compendium of Musical Technology, London: Faber & Faber, 1992, p.100.

[7] Lawrence Casserley, “Reflections on Ten Years of Electronic Music at the RCM,” RCM Magazine, vol.75, no.3, 1979

[8] Francis Routh, Contemporary British Music: The Twenty-five Years from 1945 to 1970, chapter VI, The Contemporary Scene. Available at http:// www.musicweb- international.com/routh/Contemporary.htm

[9] Ibid.

[10] Michael Kassler, “Report from Edinburgh,” Perspectives in New Music, vol.7, no.2

(Spring, 1969) p.178. Kassler is reporting on the IFIP ’68 conference.
[11] R.A.Moog, “Voltage Controlled Electronic Music Modules,” Journal of the Audio Engineering Society, vol.13 (1965), pp.200-206.

Beginning Electronic Music

Tristram Cary - Part 3

Published by Stephen Jones

In 1965 Moog and the American composer, Eric Siday, conceived a single package which would contain versions of the many different devices used in the studio.[1] Moog then assembled these into a modular system containing several voltage controlled oscillators, voltage controlled filters, envelope generators and voltage controlled amplifiers in a single package. As I mentioned in Part 1, until this time most electronic music had been produced within workshop-style studios using an assemblage of electronic test equipment (function generators and filters and the like) and hand built special purpose devices. What Moog did was to build the first 'synthesiser', which he began selling in America. However they were very expensive in Britain and were out of reach of most composers in Britain at the time.

One of these was the Australian composer Don Banks. He was resident in London in the 1960s, a friend of Cary's and also wrote film music. He got interested in electronic music and, in 1968, went to see Cary and Zinovieff, asking them to make him a small voltage controlled synthesiser for £50. With Cockerell as the main electronic designer, they mapped out how to build what became the VCS1,[2] of which three were built. One of those three is in the collection of the Powerhouse Museum [H9953-13].

By 1969 they had established the company Electronic Music Studios (EMS) and began marketing the VCS3 (a larger version of the VCS1) with 3 VCOs, a VCFilter, an envelope generator and other interesting modules. Again the electronics were designed by David Cockerell, the case was designed by Cary and the whole project was supported by Zinovieff. Apart from its small size the most interesting aspect of the VCS3 as against the American synthesisers of the period was that it used a small plug settable patching matrix to connect the outputs of sources to inputs for control of audio waveforms.

The VCS3 was a revolution. Here was a cheap modular synthesiser built into a conveniently organised box with a set of useful sound sources and modulators, a push-pin patching system (which meant no cables all over the work surface), and a joystick that could be patched to sweep the oscillators or the filter or pan the sound between channels. EMS sold it into educational institutions and many of the bands of the time took an interest. Pink Floyd made several of their records (e.g., Meddle, Obscured by Clouds and Dark Side of the Moon) with its aid.

Cary wrote the manual and had a couple of them in his studio. In its earliest incarnations it did not have a keyboard and it wasn't really designed for keyboard music. The VCS3 had one other special advantage, apart from being

comparatively cheap, and that was its stereo input channel which meant that other sounds could be processed with it. Musician Robert Fripp used the VCS3 with his band King Crimson and he used the input channel to process his guitar on his collaboration with Brian Eno, No Pussyfooting.[3]

Three VCS3s in Cary's Fressingfield studio. The furthest one is the prototype; the two nearest the camera are standard versions.

EMS then built a brief-case housed version of their VCS3 which became the Synthi A. David Cockerell designed a digital sequencer that was used in the sequencer version of the Synthi A known as the Synthi AKS because it had a touch panel keyboard and the sequencer in the cover of the brief case. Cary also has a very interesting sequencer in his collection of electronic

instruments [2009/83/10], though it was possibly designed and built in Australia.

EMS also built a large synthesiser known as the Synthi 100. It had twelve VCOs of differing frequency ranges, eight VCFilters, three ring modulators, a 256 step digital sequencer, a pair of 60 x 60 pin Matrix patch panels, eight output amplifiers and eight input amplifiers.[4] It was designed to be computer controlled and one lived in Zinovieff's studio in London patched up to the PDP8s which were operated by a program called MUSYS. Two are known to have come to Australia; one to the Music Department at the University of Melbourne and one to the University of Queensland.

Cary was invited to Melbourne in 1973 to show the staff at Melbourne University how to drive their newly acquired Synthi 100. He visited in August and found he had also been booked to present a number of lectures at various venues across the country. The result of this was that in 1974 he was invited to take up the position of Visiting Composer at Adelaide University and was then offered a permanent teaching role. He moved to Australia, shipping the Fressingfield studio.

Cary in his Fressingfield studio, with a score.

His last project before leaving the UK was his Divertimento (1973) for Olivetti machines, 16 singers and jazz drummer. It was commissioned by Olivetti for the opening of a training facility in Britain. The sounds of the Olivetti

machines, from typewriters to computers were recorded in their showroom and then digitally processed at EMS.[5]

On arrival in Adelaide he established a teaching studio in the Elder Conservatorium at the University of Adelaide and also re-established his working studio in his home, which included much of the equipment from Fressingfield.[6] He brought out his VCS3s (now in the electronic music studio at Adelaide University) and at least some of the earlier hand built instruments including the VCO, the envelope shaper, an 8- octave filter bank. He also appears to have continued developing his own pieces of equipment, for example a digital sequencer which was built from packaging brought over from the UK was probably constructed in 1976 [PHM: 2009/83/10]. Having been part of the computer controlled synthesis project that was the real purpose of EMS in London, while at Adelaide Cary returned to his interest in computer music. He began teaching a course in digital synthesis and computing techniques around 1974, which became the Computer Music Studies course in 1980.[7] In 1978 the Conservatorium purchased a Synclavier for the electronic music studio and Cary began producing works in computer music around 1979 while visiting Stanford University but his main body of computer work was done in Adelaide. Cary retired from the University in 1986 but kept on making his music. He died in Adelaide in 2008.

[1] Trevor Pinch and Frank Trocco, Analog Days: The invention and impact of the Moog synthesizer, Cambridge, Mass.: Harvard University Press, 2002, p. 56.

[2] Andrew Ford, “Interview with Tristram Cary,” for the ABC Music Show. Available at http://www.abc.net.au/rn/musicshow/stories/2006/1718642.htm

[3] Pinch and Trocco, Analog Days: pp.293-4.

[4] http://www.thesynthi.de/index.php?/archives/56-EMS-Synthi-100-Specs..html

[5] Kaye R. Fitton, Tristram Cary: Pioneer of Electronic Music in England, Masters of Music Thesis, Adelaide: University of Adelaide, 1983 (University of Adelaide Library – AV 09MU.M, F547 c.2/1-3).

[6] Tristram Cary, Illustrated Compendium of Musical Technology, London: Faber & Faber, 1992, pp.xxviii-xvix.

[7] Ray White (2004). BBC Radiophonic Workshop: An Engineering Perspective, chapter 2 [http://whitefiles.org/rws/r02.htm]

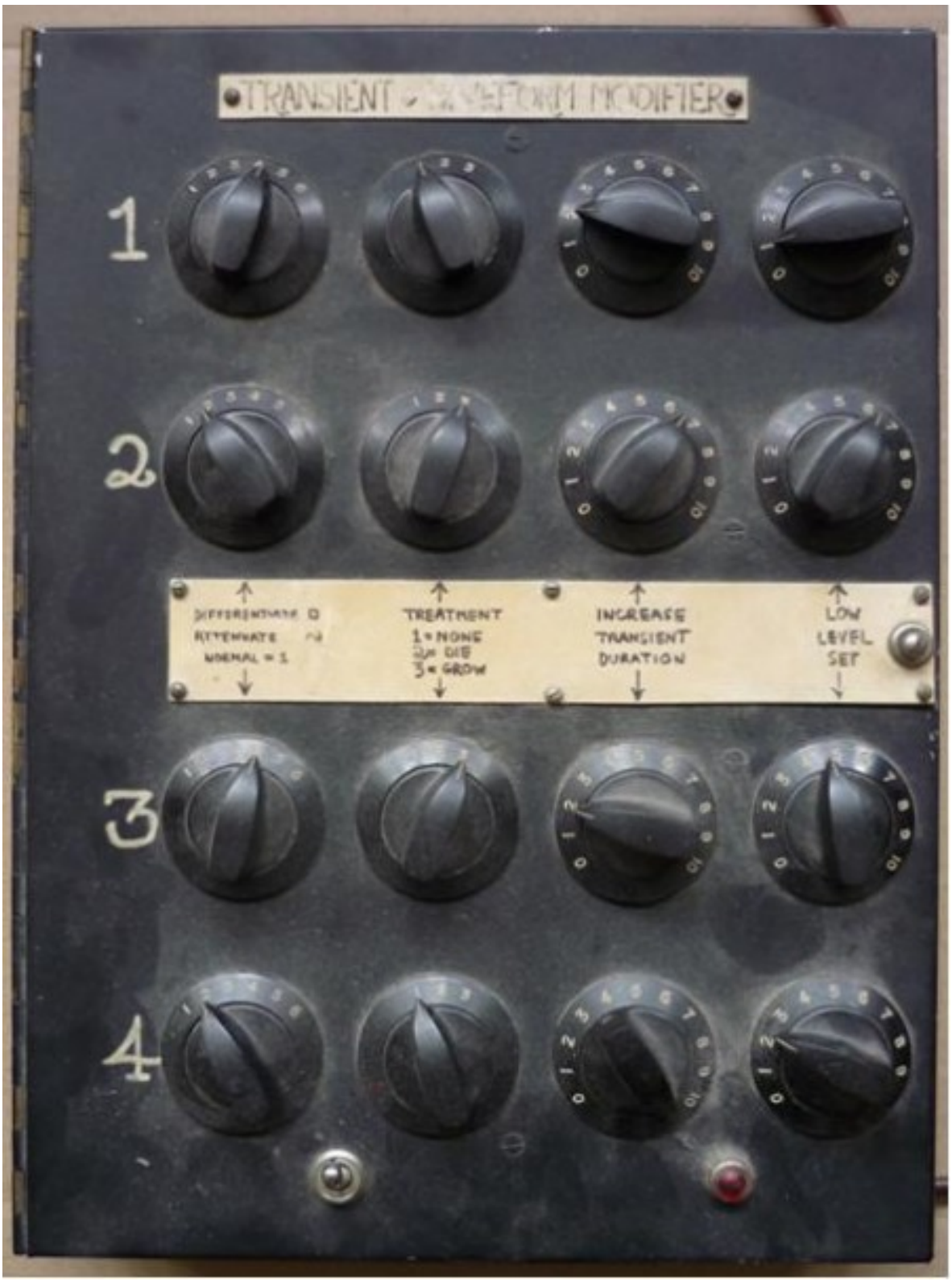
Beginning Electronic Music

Part 4

Published by Stephen Jones

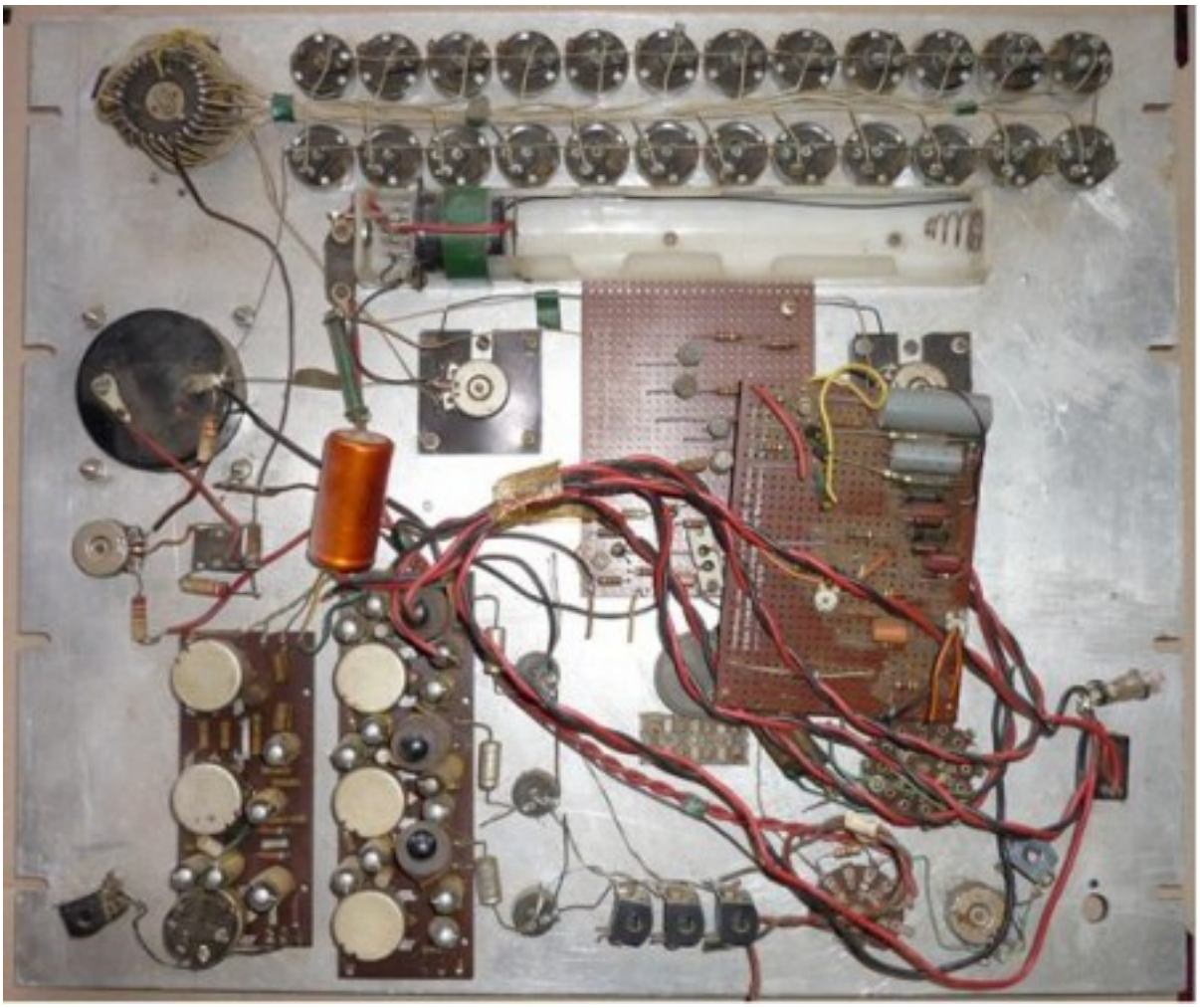
Of the objects that the Powerhouse Museum collected from the Tristram Cary estate there were several that obviously pre-dated the EMS gear and which, by my guess, were built in the early to mid 1960s.

One of these is an early version of a Voltage Controlled Oscillator (VCO). In its original state it was hand mounted on a black metal panel (approx 40 x 45cm) which has notches cut into it to allow it to be mounted in a standard 19-inch rack. There are numerous controls on the panel. Across the top it has two rows of 12 pre-settable potentiometers (24 in all) that are wired to a 30-position rotary switch, which can sequentially select from each of the presets. The potentiometers lack knobs and are set with a screwdriver so that once set the user would tend not to change that setting. Below the potentiometer pre-sets are two potentiometers with large hand-sized knobs that would give some measure of fine control and whose wipers are also applied to the 30 position switch. These control knobs are mounted on a rectangular panel with a white surface on which there are traces of control position markers written in wax pencil. The rotary selector switch also has labels for a further four external control voltage inputs.



Obviously with the pre-set potentiometers and using the rotary switch the composer could step through a sequence of voltage levels each of which is sent to the oscillator control voltage input. Thus we have a device for which the output frequency of the oscillator could be left set, or operated as a kind of manually timed analogue sequencer, or swept through a frequency range, as the composer desired.

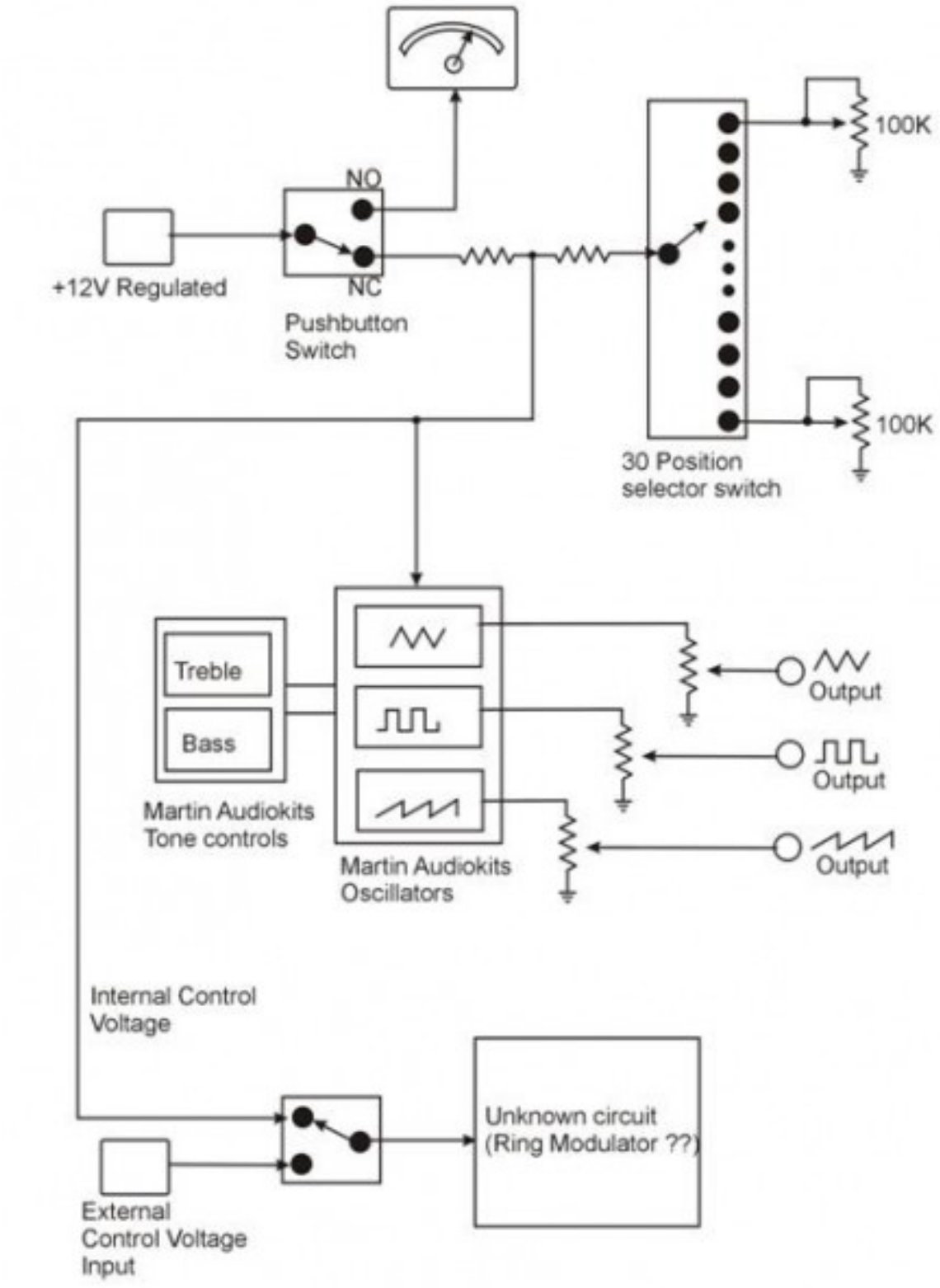
To the right hand of this central panel there is a voltage level meter. Below the white panel are an external control voltage input, a two position switch to select between internal and external control voltages, and the controls for the oscillator. The oscillator has three output jacks for square, triangle and sawtooth wave outputs plus a fourth summed output. Its design may be as a relaxation oscillator that generates a sawtooth waveform which is then put through wave-shapers to produce the triangle and square wave outputs. Each shaped output is decoupled from the supply voltage, sent to an amplitude setting potential divider and thence to the output jacks marked DC outputs. These outputs could then function as control voltages. The oscillator outputs are also summed together to produce an AC output signal.



The back of the oscillator. You can see the printed circuit boards of the oscillator and the prototype boards of what may have been the ring modulator.

The oscillator section consists of a pair of printed circuit cards. On one is the oscillator and on the other is a hi-fi pre-amp style tone control (treble and bass cut and boost). Both cards were manufactured by Martin Electronics of Middlesex, (London, UK) and were presumably sold as kits ready to be wired in to an amplifier or test instrument project. These were presumably purchased ‘off the shelf’ and built onto the panel with the voltage setting controls, by Cary. The tone filters appear to be primarily passive and are set

between the summed AC output of the wave-shapers and the output jack, giving a further level of wave-form shaping. The output must have been of rather high impedance. If anyone can tell me more about the Martin audio kit products I would be very interested.



Block Diagram of the VCO/RingModulator from Tristram Cary's Adeliade Studio.

Cary has labelled some of the controls on the panel with Dymo tape to indicate their purpose and has run arrows in strips of white tape indicating the connections of the circuits and the signal flow between them. Many of the controls are marked with coloured paper dots to enable the user to distinguish which controls appear at which outputs or contribute to those output signals.

This device can be seen in photographs of Cary's Fressingfield studio (see the picture in part 2), and in a photograph in his paper on Electronic Music published in *Audio Annual 197*1 [1] it is labelled as being a Double Ring Modulator. The object the Powerhouse Museum received is missing the large knob that switches through five positions labelled 1 – 5. The connections on the back of the switch have been cut and the whole unit appears to have been modified at some point. On the back of the panel are a pair of circuit boards which have a hand-built circuit of presently unknown purpose although these may have been the ring modulator circuit. Sadly I haven't had the opportunity yet to reverse engineer these custom-built boards so that I can work out what the circuit actually does, but the paired transistors suggest some sort of modulation device.

This ring modulator cum voltage controlled oscillator cum sequencer and sweep generator is a really interesting example of the kind of carefully considered purpose-built devices that were used in many of the studios where electronic music developed. It is a one-off. I don't know what pieces of music is was used in (more work to do there) and though it was probably built in the mid-1960s it was still in use when Cary added his VCS3s to the studio, and he brought it to Australia when he moved here in 1974.

[1] Tristram Cary, 'Electronic music – background to a developing art', Audio Annual 1971 , (pub. Hi-Fi News), pp. 42-49.

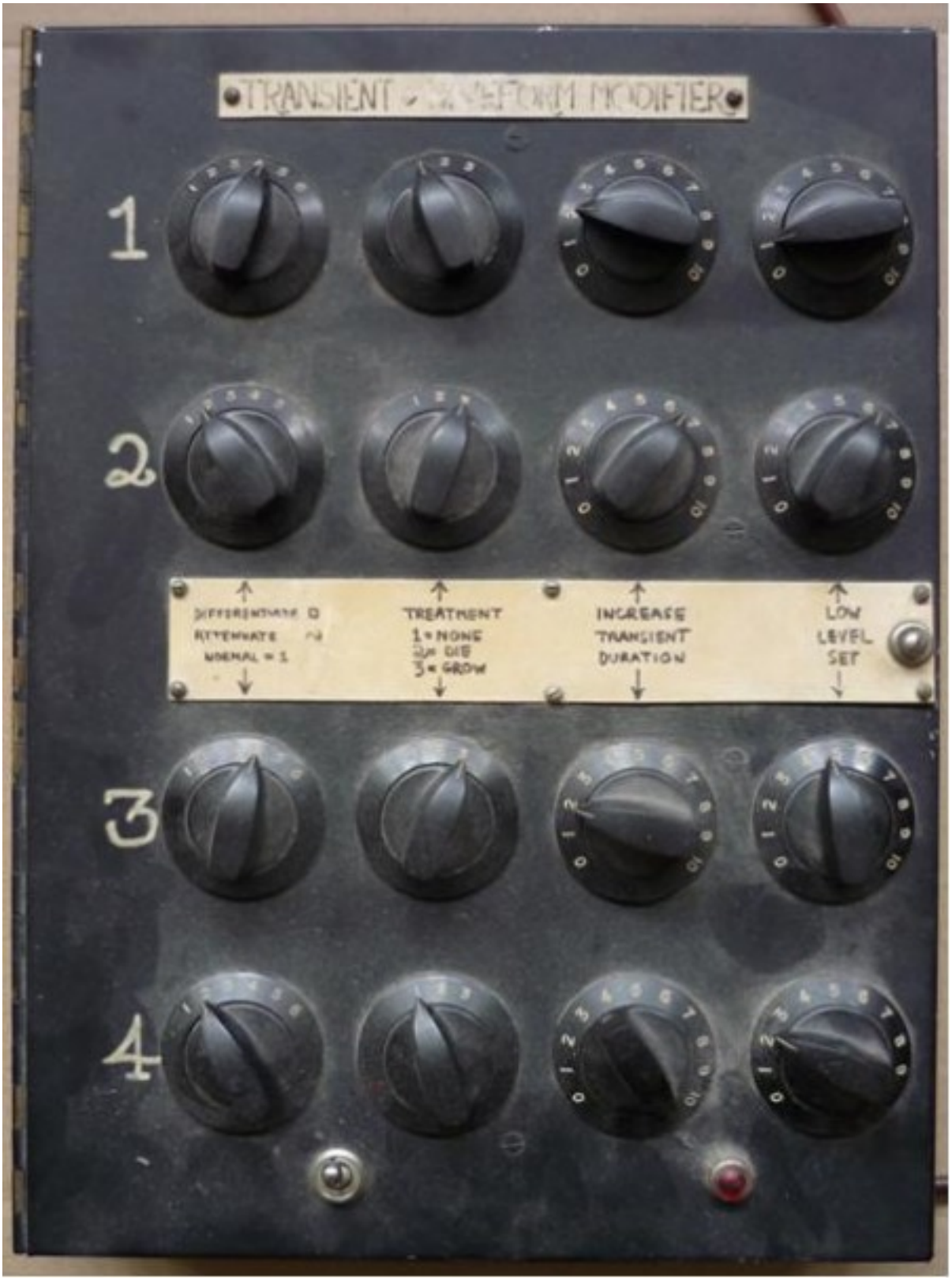
Beginning Electronic Music

Part 5

Published by Stephen Jones

This is another of the objects that the Powerhouse Museum collected from the Tristram Cary estate. It too pre-dates the EMS gear and, by my guess, was built in the early to mid 1960s.

It is a hand-built device labelled as a Transient Waveform Generator.



Tristram Cary's Transient Waveform Modifier. Collection: Powerhouse Museum

A transient is a voltage pulse that is generated to trigger the envelope of a sound. Functionally, this particular device is a ‘pre-standard’ version of an envelope generator and would have done something akin to what the combination of an envelope generator and a voltage controlled amplifier (VCA) are used for in most analogue audio synthesisers.

Given a continuous tone from an oscillator, in order to use it musically you need to be able to have it rise and fall in intensity and to sound for durations from a short sharp pulse of tone to a sustained note. To do that with an analogue synthesiser one would set the rise, sustain and fall durations of the envelope generator as desired, patch it to control the gain of a VCA, and then trigger it with a pulse of short duration (a transient). The shape, or profile, of the envelope controls the amplification of the continuous waveform by contouring the sound in a form of amplitude modulation and in modern synthesisers the envelope generator usually incorporates attack, decay, sustain and release (ADSR) periods.

Before synthesisers, while all the devices that are now readily available were being first thought about, various types of signal would have been available, from the pulse generated by a press of a push-button switch to a continuous series of pulses generated by an oscillator, the sine-wave or ramp-derived tones generated by an oscillator, to the effects of putting passive components such as a capacitor to ground (which produces a time delay as it is charged with current from the pulse source) in the signal path. What was not at first available was the voltage controlled amplifier.

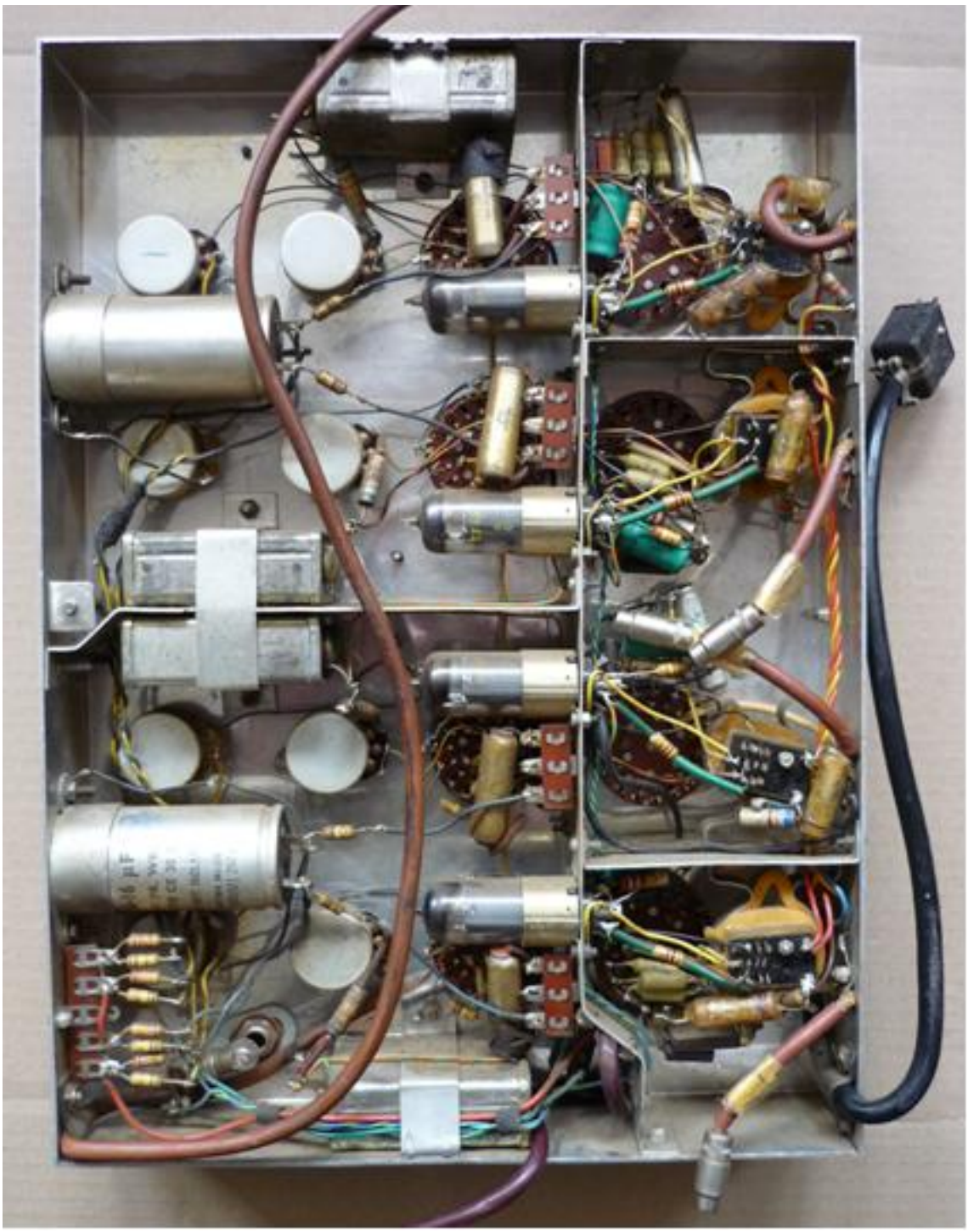
Electronically, it consists of four independent channels each of which utilises one row of control knobs. Each of the four rows consists of two multi-pole switches and two potentiometers. Behind the metal plate are the electronics for the four channels. These include the body of the switches and the potentiometers, an EF40 pentode audio amplifier valve, and the necessary passive electronic components to connect everything up and shape the currents so that the device works.

The left most control is a 6 position switch that sets the degree of differentiation performed on the transient pulse. Differentiation causes the signal to be sharpened up and may be thought of as the “attack” rate (slew rate) of the control voltage envelope. This control sets the rise time or ‘attack’ of the envelope.

The second control is a three position switch which determines whether the envelope waveform triggered by the transient continues to ‘grow’ (or rise) or ‘die’ and drop away (or release).

The third control is a variable potentiometer that sets the duration of the active period of the envelope, that is, it sets the hold period of the note being shaped.

The right most control is a potentiometer labelled Low Level Set. I suspect that this will be the level of the voltage held during its interim period or the voltage that it remains at between transient events.



The back of Cary's Transient Waveform Modifier. Collection: Powerhouse Museum

The EF40 pentode is an audio frequency amplifier valve. It has a screen grid as well as a control grid to reduce internal stray electron noise. The control grid regulates the flow of electrons from the cathode and is effectively the signal entry point for the amplifier. However if a variable voltage is applied to the screen grid then the amplifier acts as a multiplier with the screen grid voltage modulating the gain of the valve. This makes it a voltage controlled amplifier (VCA) and as such this would have been how it was used in Cary's Transient Waveform Modifier. The EF40 pentode is built to reduce sources of noise, with special mica supports for the grids, which reduce microphonics, and has very low hum characteristics, as all sources of stray magnetic fields

generated by its heater and other grids are suppressed. Leakage currents are suppressed by keeping the electrodes separated as far as possible. It is quiet enough to render it very useful in circuits that require low noise characteristics (such as audio pre-amplifiers).

See http://www.r-type.org/pdfs/ef40.pdf for valve specs, and Eric Barbour's "Audio Synthesis via Vacuum Tubes" for some notes on its use as a VCA.
http://www.pentodepress.com/receiving/pentode-gain.php