Electronic Music by Tristam Cary

Background to a developing art by Tristram Cary*
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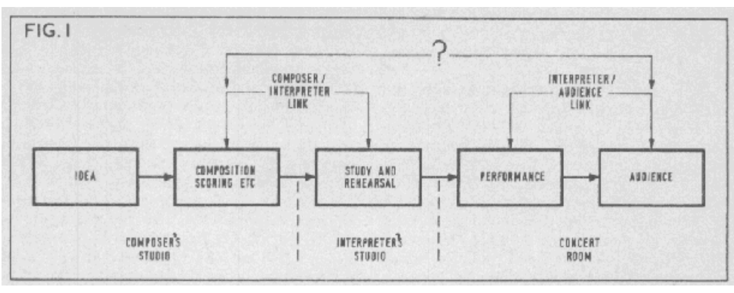
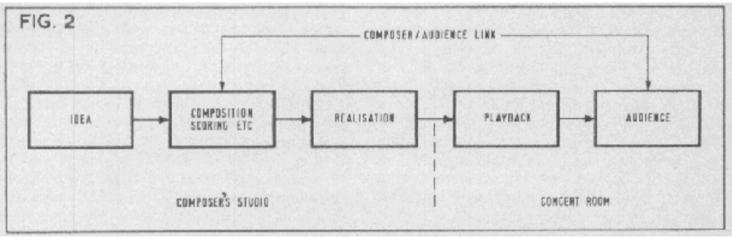
- IN casual conversation with strangers, I always try to conceal my occupation. At most, I will admit to 'musician', but even this is bound to lead to 'What sort?' 'Well, composer, actually, and I conduct sometimes'. 'Oh, how interesting, what sort of music?' 'Son of serious you know, not pop on the whole.' 'Well, I don't know much about it of course, but I do like something with a good tune.' 'Of course, well I mean, I do write tunes myself sometimes, you know.' 'I can't bear all this dreadful modern stuff, can you?' 'Well, I can bear quite a lot of it, you see, because I'm sort of involved in it, though of course I don't like it all, and there's a good deal of rubbish about, always was.
- By this time all the red lights are flashing, but it's too late. In most cases we reach an amicable impasse after twenty minutes of me tr'ying to explain what Cardew, Cage, Boulez, Xenakis, Birtwistle, you name him/her, are up to, without any real success, and switch to an easy, lighthearted subject like pollution or Vietnam. But I still count myself lucky if I have kept out that devilish word-of-the-age- Electronic. This is a real witch's cauldron of a word, thrown about, dropped, misconstrued and twisted, a suitable qualifying adjective for anything from Kar Kleening Kloths to teddy bears, often associated with miracle, age, brain, revolution and other evocative notions. So it is not surprising that when linked with the word 'music', that word which conjures up a gentle, ancient art of quiet people, sober surroundings and antique instruments, the word 'electronic' causes a mental thrombosis in all but the most hardened philistine, the most outrageous youth, or, of course, the practitioner of electronic music. To the lover of the traditional, it is tantamount to saying 'frozen warmth', or at the very best 'technological art'. Either way it seems to he a contradiction in terms, But is it? We shall see.
- Let me first of all remove some apparently widespread misconceptions:
  - (1) That electronic music is very new. Wrong. It's coming was seen in the 20's, and realisation began in earnest a quarter of a century ago. There are now hundreds of studios, 6000 or more serious works and countless commercial ones in the world's corpus.
  - (2) That electronic music is seeking to put musicians out of a job. Wrong, or only right at the crassest and least interesting end of the business, The interpretive musician is the only means by which to realise music written for instruments, or in a style designed for instruments. This is not what electronic musk is about. How about Switched On Bach, you say? Well, this proves the point in a way. It is not an original piece of composition, but an arrangement of Bach. And it is indeed a performance of instrumental music, although multi-tracked. So to include it really begs the question, and however ingeniously the electronic treatments are used it is really in the same category as a recording of an instrumental performance.
  - (3) That electronic music is trying to be iconoclastic. Wrong. The progress of art is by evolutionary change, not by sudden revolutions. Books about music often tell us of the dramatic effect of such and such a work 'which had all Europe buzzing in a few days, After the Paris performance of K s new symphony music would never be the same again'. Rubbish. Not only is there a continuous co-existence and overlap of at least a thousand years in musical ideas (do we not owe the foundations of our tonal system to the philosophy of Plato and the physics of Pythagoras?), but at a given moment of time there are sixty years or so between the oldest and youngest composers working, and even in one country, let alone the whole world, about six different philosophical concepts current at the same time. The idea that electronic music should seek to supplant established methods and masterpieces is as absurd as it is impossible. Music is a great big art, the biggest of all, and there is plenty of room inside.
  - (4) That electronic music (let's say e.m. shall we?) is cold and technical and therefore inartistic. Wrong again, or at least wrong if it is written by a composer, and we have to acknowledge that 'music' in the sense of programmed non-literary sounds can be put together in a completely amusical way. The notion that to use a razor blade instead of a bow, a computer instead of score paper, is somehow less creative, is a misconception of creativity. Creation is ideas, and how the ideas get to an audience is technique. If our ideas are poor, pencil and paper will save us no more than will Fortran. If the ideas are good and truly musical, we should be able to find the right technique to express them, and this may involve oscillators or oboes or both. The difficulty is to judge whether a composer's ideas are good or not when the medium is unfamiliar, but this is not really something the composer himself can worry about. It is unavoidable that in our own period we have to listen to a good deal of junk along with the good things, because there has not yet been time for the junk to sink to the bottom of the heap. This is your chance to claim that it's all junk, and you may of course he right. This alone would make it a completely unique period in the whole history of art, and worthy of special mention as The Great 20th Century Lacuna. The fact is that e.m. cannot he separated from i.m. (that's right) since many of the aesthetics have developed together for 20 years or so. Vituperation directed at e.m. often turns out to indicate that the complainer has not come to terms with any of the new music. E.m. has been part of the musical life of the world from about 1950 onwards, and it cannot he judged in isolation from the rest of the music around it or divorced from its immediate prehistory.
- In the first few years of the century there arose a composer who, realised that music was more than the sounds made by musical instruments. Luigi Russolo (1885-1947) invented special noise instruments and scored for them. So far as can he seen from the tiny fragments remaining, Russolo was certainly an important pioneer and may have been a genius. But 1913 was too early (the old story). His concerts caused more disorder than even Stravinsky could manage, and when the dust settled on poor Russolo nothing of consequence remained for us to study. But the ice had been broken (figuratively speaking). Edgard Varese was another matter. A man of vision and a composer or greater stature than Russolo, Varese was also far ahead of his time, but at least lived long enough to do one imponant electronic piece (Poeme Electronique, Brussels World Fair 1958). When one sees how many people's minds are already encrusted with rigid concepts at 30 (and there are plenty), it is an inspiration to picture an old man of 73, vibrant and young in imagination, making a piece for 400 loudspeakers, using oscillators, transformed voices and hell sounds, with the verve of a young student let loose in an e.m. studio for the first time. Varese foresaw it all in the 20s. He predicted e.m. and guessed where its strengths would lie. The beginning of actual realisation had to wait another 20 years for the technical resources to be available, but the ideas were there much earlier.
- Let me make a comparison. Instrumental music, as we have said, depends on a perforrner, and the composer reaches his audience at one remove.
- The progress of a piece is something like fig. 1.



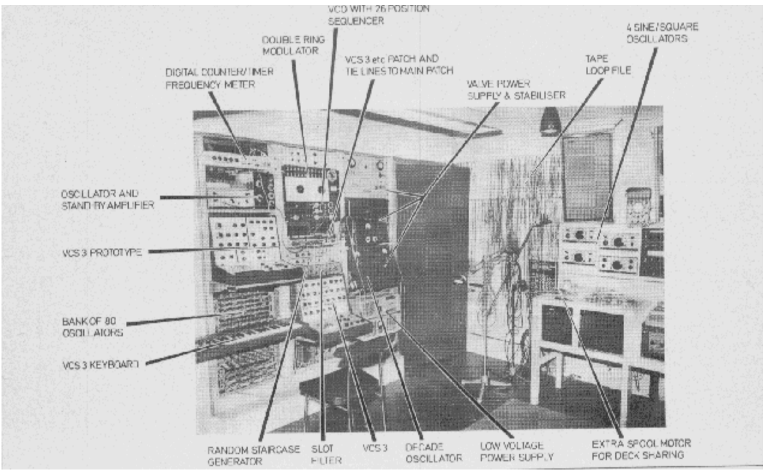
- The first dream of Varese and others after him was of a musical technique by which a composer could himself handle complex material, and himself present it to an audience in as direct a way as a painter hanging a picture on the wall.
- The flow of the musical idea would go like fig. 2.

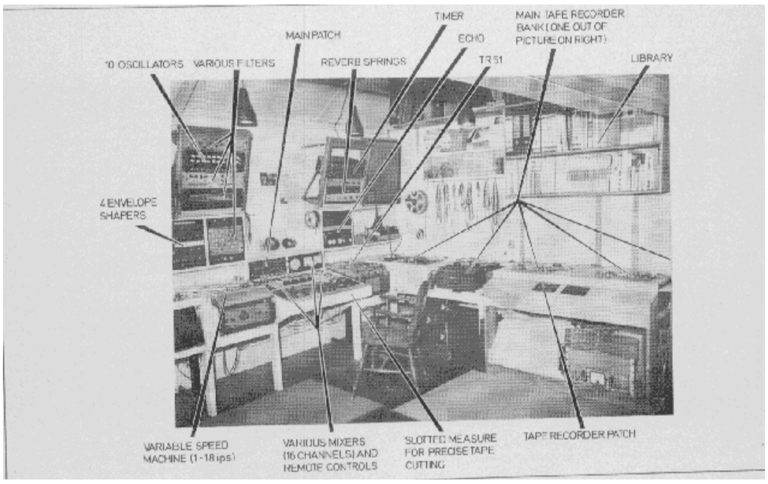


- When the first experiments were made in the 30s and 40s, composers of imagination were trying to realise a completely untrodden field, and it took a long time (in fact it hasn't really happened yet) for more than a few people to see what they were about. Let us consider, therefore, some of the new possibilities which opened up to the early workers in the medium:
  - (1) For the first time the composer could handle and control the actual sound material himself and present it directly to an audience (one parallel in traditional music virtuoso composer/interpreters like Paganini, Lizst).
  - (2) The composer's material could include any sound at all, not merely those belonging to the classical orchestra. He could, if he liked, use natural sounds.
  - (3) Purity and exactitude could be obtained by going back to acoustical first principles instead of accepting a 'ready-made' timbre possibly designed in the 17th century,
  - (4) It was possible to compose and realise music which literally could not be done at all on instruments, and explore new structures too complex for human performers.
- Examples are:
  - (a) rhythmic structures of great accuracy, complexity and rapidity;
  - (b) perfect harmonic relationships not compromised by equal temperament;
  - (c) even production of timbres over wide ranges without limitations of instrumental compass.
  - (5) It was possible to add a new parameter to musical structures by moving sounds about in relation to the audience. This cannot be done in instrumental/vocal music (except to some extent in opera) unless members of the orchestra ride about on trolleys, and even then it would be difficult to move a live sound image from the stage to the back stalls in, say, 10 mS. (I once did a whole stage battle with two very exhausted trumpets dashing about all over the theatre playing 'friendly' and 'enemy' fanfares from all available openings.) The above points do not exhaust the possibilities by any means, but will do for the present.

- In 1948 not all of these ideas could be realised. We had all heard of tape recorders but few were available. Wire recorders were quite hopeless for high quality work. The essence of composer-realisation was to present the music as a recording, and the only good quality medium was the disc, so that is what we all used in those days - 78 r.p.m. at that! Athough I hear laughter from children of the IC age that I should dare to mention 'quality' in the same breath as 78 r.p.m. discs, may I remind scoffers that a freshly cut acetate is a very quiet recording, and had a very decent range provided you didn't cut too near the middle (I used to record inside-to-out anyway to avoid swarf problems). Furthermore, any part of a disc has very much quicker access time than a tape, making surprisingly rapid editing possible wtthout stopping the recording. We had turntables variable from 20-200 r.p.m. We had reversing turntables with left-handed pickups. We ran a train of pickups behind the cutter for echo. Of course we had a lot of quality trouble - I freely admit it - but we had no tape and no special e.m. circuitry (and no money and nobody interested) so we did our best with what we had. The two Paris Musique Concrete discs (DUC8 and 9) which have been available for some years now, contain several pieces in which you can clearly hear the 78 per minute repetitions of closesl groove disc loops (and the surface noise).
- Naturally the arrival of high quality magnetic recorders was the first major revolution in the infant techniques we then employed: Apart from optical sound track (whose quality was very poor then, none too good now) this was the first generally available recording method which allowed sound to be cut and manipulated. The exciting possibilities of juxtaposing fragments of sound from different sources, and very easily changing time-scales, speeds and directions, all became realities. Furthermore, and very important to poverty stricken solitary workers, tape could be wiped and re-used, whereas expensive acetate blanks could not.
- At the time of British professional machines like the EMI BTRI, those who could not afford such luxury could purchase the Sound Mirror; but compared to what I could obtain with my good MSS cutter the quality was poor. My first adequate tape machine was an early Bradmatic deck and the electronics they recommended for the heads supplied. This still works well after 17 years or so, though I use it for playback only these days, and the electronics are solid-state instead of valves.

- Right: two views of the author's studio at Fressingfield, Suffolk (Classical Studio with some Voltage Control). Behind racks: 80 oscillator controls, percussion generator. Out of picture; two 100W amplifiers, two Tannoy speakers.



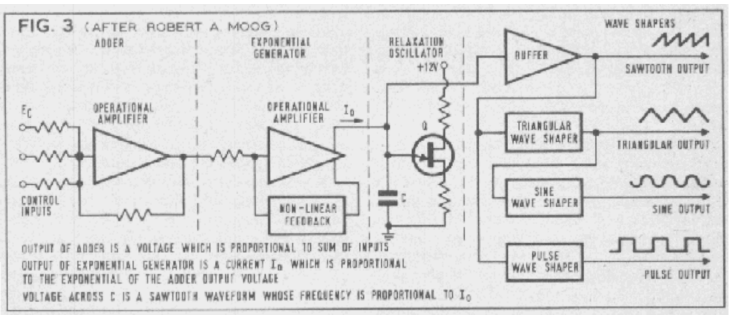


- The aims of musique concrete were to liberate l'objet sonore, as Pierre Schaeffer calls it, and to regard any 'sound object' as a possible artistic unit in its own right-not to think of some sounds as 'musical' and others as 'unmusical'. The composer's art lies in what he does with the sound, and although some sounds are naturally much more interesting than others, there is no sound which is positively inadmissible as musical material. Physicists had long before shown that all spectra are analysable into sinewave complexes, but the rationalisation of this is to take 'sine-tending' sounds such as those having periodic groups of partials and discernible pitch organisations as one group, and 'noise-tending' sounds, or spectra of high density containing much randomly aperiodic material, as another group. In pure electronic music, too, a general choice is made between building up to the complex from the simple sine, or building down by filtering noise.
- Over the years the Groupe de Recherches Musicales or the ORTF in Paris, under Schaeffer's supervision, has researched 'l'objet sonore' very thoroughly, and the Paris school has held firmly over twenty years of development to the idea of the complex, interesting sound as raw material for music, rather than the notion of electronic synthesis from basic generated sources.
- From the listener's point of view, an adjustment needs to be made to the idea that sounds other than tunes, harmonies or other traditional building blocks can also be valid structural units. It requires much the same adjustmeat, though an opposite one to some extent, to see the point of some sorts of abstract painting. A 'blue cloak' is really a blue form on a plane, and this form has validity even without the fact that it represents a cloak. So there is no need to ask 'what is that blue form a picture of?'
- In music, there are several aesthetic standpoints from which we can look at a sound. A 'note' as a step in a melody has no absolute validity in this context except as a part of that melody. It has timbre certainly, but probably the sarne timbre as its neighbours, the whole making, say, a tune on the guitar. This is the classical concept of the role of a sound-it is part of a time structure of tunes, phrases, movements, and a vertical structure called harmony. But when musical colourists appeared, along with the rich resources of the 19th century orchestra, composers began to see value in sounds for themselves, whether as parts of tunes or not. The atmospheric textures woven by Debussy require us to listen to the sound for itself, whether or not it is part of a tune or a phrase (one test of colour-dependence is to see how well an orchestral piece survives piano reduction). In musique concrete the composer takes a sound and pulls it apart, exploring the various possibilities of its internal structure. The original identity of the sound rnay be left as a literary reference, or removed. But it should not be necessary to ask yourseff 'what is that sound?' - it must be regarded as a musical phenomenon in itself.
- In contrast to Paris, the early electronic music coming from Cologne a little later (early to mid fifties) abhorred all this use of recorded sound, and went completely the other way. It is an accident of history that electronic music arrived at a time when most of the younger composers were under the spell of serial techniques. The music of Schonberg, Berg, Krenek, Webern and others of the second Viennese school were the scores being studied. For the serial composer, the strength of the music lies in the precision of its organisation.
- Let me explain. The classical scale or mode is a hierarchy of related notes, a pecking order with tonic at the top, dominant close behind, and so on with each degree of the scale having a different harmonic tendency and force. The chords of thirds (triads) derived from the notes combine to make cadences and progressions. These gravitational pulls within the scale are caused by the fact that the intervals vary - most of them are whole tones but two of them are half tones - consequently the chords vary in shape. The position of these half tones decides whether the mode is major or minor, dorian, aeolian, what you will. Because the half tone is the smallest interval used, an octave of twelve equal semitones yields all these modes at all pitches (not accurately, though, but I do not propose to discuss temperament here). So after centuries of modal and tonal music the Western tradition had settled very firmly for a standard smallest interval of a twelfth of an octave - an increment of the twelfth root of two.
- The new composers took this group of notes and made a new kind of counterpoint in which all twelve notes had equal status (no tonics, dominants, etc), and the equal status was guaranteed by giving each note an equal exposure. A serial composition begins by the composer choosing an order, or series, for all twelve notes (an octave, the thirteenth note, counts as a unison). This is the 'tone-row' for the piece. It is not a tune, and may never appear in its basic form, and furthermore it can be transposed, inverted and/or reversed, giving 48 different forms of the row.
- It was necesaary to explain this to see how the musical thinking of the time influenced the early electronic music. In serial instrumental music up to that time, more attention had been paid to serialising pitch than any other parameter. For one thing, serial treatment of, for example, dynamics or timbre is very difficult to do instrumentally. Suppose, for example, we take the dynamic possibilities as pp, p, mp, mf and ff. This gives us in theory a six-term series which can be arranged any way we like - say mp, f, pp, mf, p, ff.
- Inversion would substitute ff for pp, etc. Reversal is obvious. Transposition would only be possible if we allowed ppp and fff to shift the scale side ways. But whichever way you took at it, it is very difficult for a performer to produce an accurate dynamic series. This is why electronic music was welcomed by Stockhausen and other young composers as a heaven-sent opportunity to be completely in control of the material.
- Starting with that simplest of all building blocks - sine tone, the timbre, the pitch, the dynamics, the position (if the piece was in two or more tracks), the attack and duration, in fact all parameters of the sound could be predicted, measured and precisely controlled by the composer. Since he was not working in real time he could try again, improve and perfect to his heart's content until everything was right. The greatest achievement of the Cologne studio in this first period was Stockhausen's Gesang der Junglinge, which comes as near to a classic of electronic music as the form has yet produced. The material was meticulously serialised even to making minor pitch changes in the solo boy's recorded voice, even when required at natural pitch, since the actual recording was in most cases not quite correct.
- The position fifteen years or so ago, therefore, was that two main schools had each discovered a different mine of possibilities in electronic composition methods. Both were attempting to create a genuinely non-instrumental music, and this was, and is, the most important function for electronic music. All through the thirties and forties, when these possibilities lay dormant, the electronic organ in various forms was advancing fast, but was not attracting the attention of serious composers because of its basically imitative function, even though the electronic organ soon became an instrument in its own right rather than a substitute for a pipe organ. But the design thinking which went into organs was all instrumental in intention - attack/decay envelopes to seem like blowing, bowing or pizzicato; tremulants giving frequency modulation at more or less the same speed as human vibrato, etc. So the organ as it stood was not the right instrument for the electronic music composer.
- This remark seems to be contradicted, however, by the present spate of what one might call 'melodic electronic music', both in such records as the above-mentioned Switched On Bach and increasingly in such areas as signature tunes for radio and TV. It is certain, too, that we are in for a vogue of all kinds of electronic pop when the groups get round to it. So, did all those thoughts of the fifties turn out to

he dead-ends, and did a form of electronic organ win the game in the long run, or what? The answer is not completely simple, but quite understandable.

- In the first place let us realise that the term electronic music means at least three different things, depending on where you stand. For me it means music which I can only realise electronically. I write instrumental music too, and of course frequently mix the two. But I am not interested in synthesising an oboe when I can engage a real one. The serious electronic music of 1971 has developed from the earlier pieces in a direct evolution of ideas and hard-ware, and Instrumental music has moved along- side it. Total serialisation; for example, is no longer the aim of most music of either kind. Electronic music has in fact influenced instrumental technique, and there is now much more live performance e.m. to bridge the gap completely. All but a few young composers wish to use electronics as a matter of course.
- For another person, e.m, means 'music carried out electronically', and by music is meant tonal instrumental music. This sort of realisation has always been possible, and Tom Dissevelt's very engaging pieces of a few years ago (Phillips 430 736 PE) are evidence of a light music style using electronics which predates the synthesiser age by some years. The present spate of instrumentally inspired pieces is largely due to the greater ease with which they can now be realised.
- Yet a third view regards electronic music as music which is electronically composed. It is possible to make programs (this Arerican spelling is standard for computer programs) which will result in a computer-produced score, and its realisation may he instrumental or electronic. The results are not usually very interesting, because it is necessary to reduce composition to a kind of chess game. A typical procedure, using Monte Carlo methods, goes like this: Stage 1 - the Rules of the piece, consisting of what may or may not be done, programmed and stored. Stage 2 - given a start, the computer generates random numbers and compares them with the next step permitted by the Rules, accepting the first number which will do. And so on. The result is determined by the framework we have given-if the Rules provide more choices there will he more variations in the output. A good example of this use of electronics is The Illiac Suite (Hiller and Isaacson - Experimental Music), written in the mid-fifties and so called because that was the name of the Illinois University computer. The resulting score is for string quartet.
- In fact many subtle audio processes have been available for a decade or more, but with some technical difficulty. At the moment the whole field is in process of discovery by a much larger public (most of whom seem to think it all happened yesterday afternoon) because the new 'synthesisers' make do-it-yourself electronic music a possibility with very much less training. Let me briefly sketch the historical development of e.m. studios, which divides into four main stages:

- (1) The Primitive Studio
  Before the days of purpose-built e.m. devices such as modulators, sequencers, special filters, etc, studios used what they could find in the standard ranges of audio equipment. Most manipulations were physical - i.e. by modifying disc or tape recordings. Polyphonic montages through several recording generations. Most important tool-the razor blade.
- (2) The Classical Studio
  The best studios of this type are capable of doing very elaborate manipulations, but there is a lot of work and expertise involved. Special tape machines (multi-head, multitrack, variable speed, rotating head, etc) and electronic treatment devices now tailored for e.m. Sequencers of various sorts. for time control, reducing tape editing, but most operations still manual. Multi-track giving more flexible montaging, and four-track final tapes becoming normal. It is interesting to note in the present heated discussions about quadraphonic sound (as if it had only just been thought of) that Gesang der Junglinge (1955-6) was made in five tracks, and that most foreign studios have been issuing 4-track 1 in. masters for a decade. In the U.K., alas, both the production of music and the mounting of concerts in 4-track are usually too expensive. In a non-instrumental music, of course, multi-track is another creative tool and not an aid to 'realism', which is not a meaningful term in this context. So rotating sound, phase shifts, etc, have been standard techniques for some time. The most elaborately specified of the pre-computer studios is the RCA Synthesiser at Columbia Princeton Electronic Music Center, New Jersey. It has a perforated paper tape input and as complete parametric control as can be achieved by many hundreds of relays and electronic switches.
- (3) The Voltage Controlled Studio
  Forms of voltage control have been known for some time, but the ideas leading to the modern synthesiser were rationalised by Robert Moog five or six years ago when he published circuits for a voltage controlled oscillator (VCO) and a voltage controlled amplifier (VCA). The basic Moog oscillator is a saw-tooth relaxation oscillator (fig. 3).



- The principle is that the greater I0 the more often the voltage across C will reach the unijunction breakdown voltage, and hence the higher the frequency. A sawtooth output is useful in e.m., since it has a complete periodic spectrum and will therefore yield any group of harmonics if suitably filtered. As well as being voltage controlled, the oscillators give several different in-phase shapes from one source, and this is also a useful feature. The v.c. principle was soon applied not only to oscillators and amplifiers, but to any required parameter of any device, and the circults made more compact. Manual controls can of course he retained, and usually are, but turning a knob marked FREQUENCY simply varies a DC voltage. The advantages of voltage control are many, but here are a few of them: (a) The control circuit and the signal are quite separate, so the signal path need not be compromised in order to control it. Long, lossy, hum-tending signal lines can he avoided - for example a programme level can be noiselessly controlled along a mile of cheap cable by a two-shilling pot and a torch battery. (b) Devices can 'talk' to each other, the signal output of one becoming the control input of. another. AM and FM become child's play instead of quite difficult, and multiple parameter control is easy. (c) Automatic controls in the classical studio are confined to switclting, resulting in complex decade and sequential arrangegnents to control multi-state parameters like frequency. With v.c., analogue functions of any shape we like can he delivered. Control devices such as keyboards deliver stepped (staircase) control shapes, and for continuously changing controls a use is found for very slow oscillators with frequencies down to the order of 0-01 Hz. A device like an envelope shaper performs its normal function by applying a trapezoid waveform to a VCA, but the trapezoid function can control other parameters as well if we wish, so in the middle of the envelope a note can, for example, get louder and have its filtering changed and get higher and become more reverberant. Much more subtle timbre changes are possible, because we can use dynamic filters with v.c. of both centre frequency and bandwidth. Fig. 4 shows a patch based on one audio oscillator with certain dependencies arranged between the controls so that exact repetition will take a long time (LCM of all the cycle times). The voltage controls are as follows:

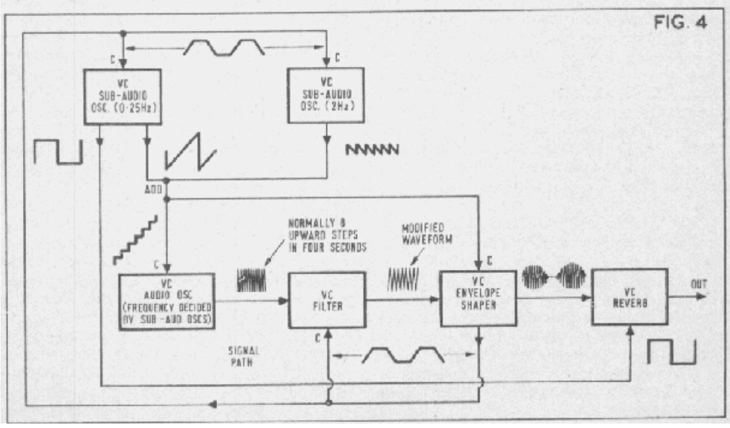
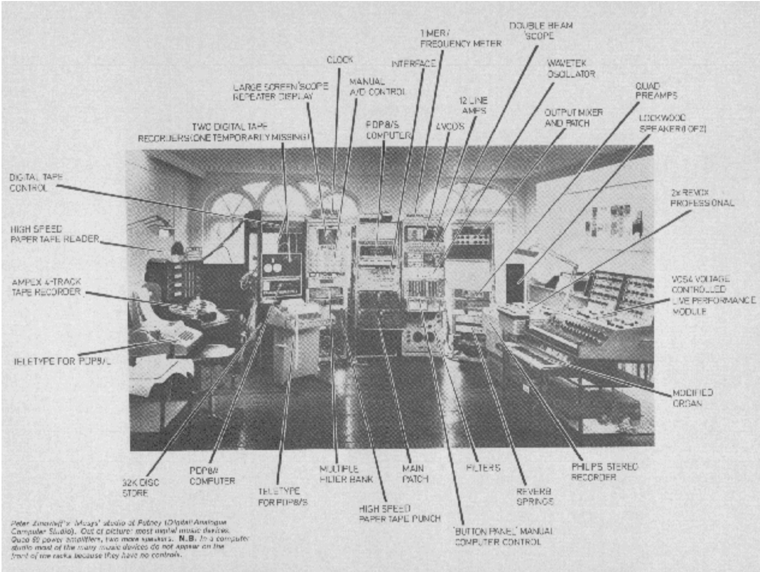


FIG. 4

- Oscillator-frequency; filter-centre f; envelope shaper - decay time; reverberation - ratio direct-to-delayed signal. Apart from the devices in the audio chain, two sub-audio oscillators are used to generate a control stair-case. What you hear: A scale of eight notes goes on continuously, but since the envelope shaper is not in sync with the slowest oscillator (at 0-25 Hz) you hear different samples of the scale each time. Furthermore, the bottom half of the scale will always have more reverberation than the top, and the scale will also speed up and the filtering become more shrill in the middle of the envelope. Finally, the envelope will be shorter (more staccato and quicker) at the beginning of the scale than the end. An assembly of v.c. and selected non-vc. components with suitable patching arrangements has come to be called a 'synthesiser'. I personally don't like the name, because it implies that its object is imitative, which for me it is not. However, with its possibilities of delicate nuance it certainly can be, and is, used to synthesise instruments effectively, and for rnany this is its principal aim. Several synthesisers are already on the market, and no doubt more will follow. The most competitively priced complete system is the VCS3 with DKI keyboard, made by Electronic Music Studios Lid of Putney, and priced at under 500 UKpounds for the complete package. The Moog was the first synthesiser available, and like the other American makes can be built up in units, though prices are fairly high for British customers. For complete realisation of electronic music a synthesiser is normally associated with studio mixers and multitrack tape recorders, some non-v.c. components, and indicators such as a 'scope and a digital tuner/frequency meter. EMS of Putney are also making large v.c. complexes suitable for universities and broad-casting companies, and these cost about 5000 UKpounds upwards depending on specification. These large units are provided with digital sequencers, delivering up to 256 successive groups of voltages at precisely controllable times. At this stage we can program quite elaborate structures and play them live without recording and tape editing. It is difficult to go beyond this without introducing proper computation, and this is indeed what the new studios are doing.

- (4) The Computer Studio
  Until a very few years ago most work with computers was directed towards total synthesis. No music devices as such are used, and the computer itself generates the sound. In the case of a function like a sine, for example, the computer is instructed to calculate a Series of numbers representing samples of the instantaneous amplitude of the waveform at, say, 10.000 samples per second. Since every complete cycle must have a minimum of one positive and one negative sample, the frequency limit is half the sampling rate (extendable by realising at slower than real time and speeding up final tape). If the note is steady the cycle can be looped in the computer. The final result is taken to a digital-analogue converter and suitably integrated to smooth the waveform. This method, the basis of quite a lot of work done in America, has the advantage that any industrial computer can be used, and that the operation is very 'clean', no jumble of oscillators and other analogue devices. But there are great problems as well. Even quite simple sounds require a vast amount of calculation, so even with fast rnachines the compilation is relatively slow and very expensive. Computers of this size and cost cannot be used exclusively by e.m. studios, so they have to he shared, and at a busy university a composer might wait weeks to get his program loaded aad processed. If he then wants to change something, as he certainly will, there is another delay. In general the frustration factor and the final cost per minute of realised music are both high. The new generation of computer studios use small, quite cheap computers which are interfaced with music devices, and this has been made much easier by v.c. circuitry because the conversion of a number to a voltage is not a difficult one. Designers such as David Cockerell of EMS are also developing devices which are directly controlled by digital data. For example there are several musical parameters for which 64 choices cover all the likely requirements. Thus an amplifier, for instance, can be controlled in single decibels using only six bits (2 6=64). The other way to do it is to interface to a VCA through a DAC. Switched functions need only one bit, of course. The result is that the available storage can be used for musically relevant data, and modest 12-bit words can he made to do a lot of work. This type of studio has been pioneered by Peter Zinovieff, whose Putney studio is the most advanced digital-analogue complex in existence at the moment. It is interesting to note that many other studios, including some American studios which previously favoured waveform synthesis, are following his lead. The input 135 normally by teletype keyboard or a special manual controller, and Zinovieff has devised a new language, MUSYS, by which the composer communicates with the studio. It is hoped that MUSYS will become the basis of a generally acceptable computer music language compatible with other studios as well. Needless to say the whole system is continuously evolving, and I still find a need to retain the possibility of using older procedures when they seem right. An obvious example is in the treatment of real sounds, where it may be more convenient to deal with them conventionally than to 'get them in' to the computer for processing (though analogue tape can of course he used as an input). The art of electronic music is not so old that we cannot retain the best of all systems which have been tried. One of the great advantages of the small computer D-A studio is that you can evolve to it from simpler systems. Beginning with some v.c. equipment, the studio can grow until it justifies interfacing the v.c. equipment with a computer. The computer, too, is expandable - more storage, more variety of inputs and outputs. Within a year or two, the cheap desk-top computer should enable a real computer studio to be built for little more than a good-sized synthesiser. Apart from the obvious advantages of multiple control, storage and mathematical capability, one of the reasons why the tendency is to 'go digital' is that although the synthesiser type of v.c. studio is at first a joy to use, the serious composer has great problems in exact control. In the fig. 4 set-up, a minute alteration in any of two dozen or so knobs will change the effect noticeably. Precision and repeatahility are absolutely essential if a piece is to be realised accurately from notation, and they are very difficult to achieve with analogue equipmeat. In my studio (no computer) I can spend hours with frequency meters, oscilloscopes and clocks setting parameters exactly as I want them. If the mains then drops ten volts (not infrequent in rural Suffolk) I have to start all over again. But a number is a number, and digitally stored instructions cannot drift in this wayward fashion. Everything is precisely and repeatably controllable, and can be stored on cheap paper tape. Indeed, it is almost certain that before very long digital tape will supplant analogue for all recording purposes. There will be no problems of longterm storage provided the playback can tell 0 from a 1 it doesn't matter what state the tape is in. Unlimited copies can he made without any degradation in the information, and the tape need only go as fast as the information flow requires, instead of running steadily through tutti fortissimi and long, crackly silences alike.



- Peter Zinovieff's "Musys" studio at Putney (Digital / Analogue Computer Studio). Out of picture most digital music devices, Quad 50 power amplifiers, two more speakers. NB. In a computer studio most of the many music devices do not appear on the front of the racks because they have no controls.

- The position at the moment is this. The synthesiser is emerging from the e.m. studio and finding a new market, and will undoubtedly sweep the musical world to an even greater extent for the next few years; as a live performance instrument, as an effects generator, as a teaching aid, as a component in an electronic music studio, or simply as a fun box, it is easy to use and attractive in its endless variety of sounds. But for the serious worker it has disadvantages, and these are being overcome by employing a computer to control the devices. This is in its turn producing a new generation of purely digital music devices, and these have no manual controls at all, optional or otherwise.
- In world terms the battle for basic recognition is won. The e.m. studio is an accepted part of any academic establishment with music in its curriculum. Efficient and compact synthesisers like the VCS3 make it possible for this trend to extend into schools, and I see no reason why every secondary school should not have its own modest e.m. studio.
- When it comes to available facilities, Britain is the worst served of all the rich countries (and compared with most we are still very rich). Everywhere else in Europe and America, even in Iron Curtain countries, and now in Asia too, good studios have been provided for the use of composers, either by the national radio network, by the universities, or by industry. The only 'public' studio in England is the BBC's Radiophonic Workshop, but thanks to a woefully mistaken policy (not to decisions by the staff of the Workshop) this studio has never been available for composers to use except on BBC business.
- There is a handful of private studios, and these are more or less badly equipped according to how much money their owners can afford to put into them. A few academic studios exist, such as the one I run at the RCM. The only studio which can be shown off with pride to international visitors is a private one Peter Zinovieff's. The position is so absurd that when students of mine finish a course at the RCM they have nowhere at all to go; no studio to work in unless (a) they are rich enough to buy one, which is unlikely, or (b) they can persuade the owner of one of the private studios to let them use facilities - also unlikely because in most cases it prevents the owner doing any work himself. Very often i have to suggest that they write abroad and ask to be admitted to one of the excellent studios existing elsewhere. I would like to make an appeal to our large manufacturers. The Philips company has generously supported electronic music in Holland from the beginning, and this generosity has done them nothing but good, both in giving them a reputation for liberal arts patronage and for the fact that a good feeling towards a company encourages orders. The actual cost of such generosity has, one would imagine, hardly shown on their balance sheets.
- Now EMI, Plessey, Pye, all of you, please copy. What we want is a National Studio, and if it is to allow a number of composers to study and work it will have to be good and it will need equipment and expertise of the highest class. Swedish radio has spent something like 300,000 UKpounds on its new e.m. studio in Stockholm. This is the kind of sum we too need. We have the best brains in e.m. in the world, but we need (a) a place, and (b) plenty of first-class hardware to put in it. Peter Zinovieff has offered to give, yes give, his 40,000 UKpounds computer studio to the nation. All he requires is that the studio should be suitably housed and maintained, which would need about the same sum again and an annual amount to run it. It also needs extra equipment -t o make it suitable for the multiple use it would be getting. There is no doubt that as the centre of Europe's music making, London should have a really first-class e.m. studio, preferably with an auditorium specially designed for multi-track listening, and suitable also for ballet, chamber music, opera and every kind of mixed-media event. The momentum of demand is increasing, with more young composers each year in search of facilities.
- For many years the development of e.m. in Britain has been left to a handful of pioneers, and although private studios will of course continue it is essential for a proper centre to exist, and very soon. The position is the same as in so many other fields of endeavour in Britain: we have plenty of good ideas - in fact people come here to pick our brains - but we have no backing to put these ideas into practice. Many of us, including possibly myself, end by going abroad to an atmosphere which is not so implacably against change, and is willing to support lively ideas with real money.
- In order to create a body of support for a National Studio, the British Society for Electronic Music was founded in 1969, and anyone who reads this article and is interested should write for details of membership to BSEM, 49 Deodar Road, London S.W. 15. Meanwhile, in spite of the lack of public support, and although i turn various envious shades of green whenever I walk into splendid foreign studios (often in much smaller countries than ours), e.m. in Britain is very much alive and likely to remain so.
- Though still in its first quarter century of development, the new music is firmly established and accepted and, because it is young and bouncy, exciting new discoveries are always being made. It may be, as some predict, that computer programming will have to be included in every composer's cirrriculum, or at least that a special breed of programmers will have to exist for musicians, What is certain, I think, is that when the time comes to review the artistic events of the century, the coming of electronic music will turn out to have been one of the most importa

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