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Interview - Peter Zinovieff

From These Hopeful Machines (/concert/programmes/hopefulmachines), 12:00 pm on 26 November 2013

Peter Zinovieff with the Synthi A (EMS Archives with thanks to Matthew Bate, used with permission)

Peter Zinovieff now (Jakob Polacsek, used with permission)

Peter Zinovieff established an independent electronic music studio around 1963. Frustrated with the limitations of tape-editing and electromechanical sequencing, he acquired a PDP-8/S computer in 1967 to control the sound-producing devices. In 1969, together with Tristram Cary and David Cockerell, he established Electronic Music Studios (EMS) to make and market a series of now-classic synthesisers including the VCS3, Synthi AKS and Synthi 100. He also collaborated with Harrison Birtwistle on 'Chronometer', and wrote the libretto for Birtwistle's opera 'The Mask of Orpheus'.

Peter Zinovieff interviewed 22 March 2010. Edited and corrected by James Gardner and Peter Zinovieff, February 2012 and further annotated in 2014.

James Gardner: How did you get into electronic music in the first place? According to the book *Analog Days* [1] you were taught by Daphne Oram.

Peter Zinovieff: I was, but I think that was slightly after I got into it. What actually happened was that I was working as a mathematician in the Air Ministry and earning not very much money. But in those days we were taxed very highly, because my wife had quite a lot of money, and so it was useless, you know, I just slaved away doing boring jobs on atomic physics. So I gave it up and decided to take up an old interest, really, which was experimental sound which I'd been involved with a tiny bit at Oxford. And then I found that I really didn't even know how to cut up a tape. So somehow I found out about Daphne Oram and asked her to give me lessons, which she did. I went to several lessons and she gave me homework like making up a tune out of bits of spliced tape and things like that; speeding up and slowing down tape recorders.

Was that when she was still at the BBC Radiophonic Workshop?

No, she was private. I knew her when she was independent. She had her own studio, so I was a private student for a bit. And it's that which made me completely frustrated with the whole idea of cutting up tape and sequencing tape in that way.

And that frustration led you to think about how one could do that with the computer and sequencing?

Well before computers, really—with sequencers. So the first thing I did was to try experimenting with uniselectors. These were the things that used to operate telephones in exchanges; when you dialled a nought it took quite a lot of time to send the pulses down: *bu-bu-bu-bu-bu-bu-bu-buh*, and then it was interpreted in the telephone exchange by these machines chugging round until at last the right number was selected. So I was able to hook up a number of these, say 20 of them, with thousands of wires and was able to control 20 oscillators in this way. But you know, I could select 20 individual pitches in whatever order I'd dialled, as it were.

That was an electromechanical process?

That was electromechanical, so there was all the thing of whatever I did to dampen the clicks, you know, there were terrible clicks and a terrible amount of wiring. And so that wasn't any good either. Then I got hold of—I can't remember his name any more [2]—

who made me a transistor equivalent, which was just a switching mechanism to switch, so you could select a number of huge oscillators which I had then—ex-Army oscillators. And so it was one frustration after another until David Cockerell came on the scene.

A lot of that early equipment would have been bought from army surplus shops and things like that.

Yes—it was wonderful. In London there was a street called Lisle Street, and it was just a succession of one shop after another selling ex-Army, -Navy and -Air Force junk. Sometimes there were huge machines with thousands of tubes and valves and dials and they

would do things like signal analysis and there were sound generators, noise generators, filters. This was all 19" rack-mounted stuff. They were very, very good; very high specs and things.

So that's the sort of gear you were working with before David Cockerell came along?

Yes. I had these great big huge chunky things which weren't any good really, because you had to sort of run a marathon to get between them. If you wanted to change a filter you had to go to the other side of a room, as it were. And anyway they kept going wrong and the valves would break and so on. So David came on the scene and…I mean he was —and I suppose still is, really—a sort of breath of fresh air to electronic music.

Why do you say that?

Well because he's got that genius of…you could say to him "I wonder how I could have this—could you make me this?" And he'd look at you blankly for about 10 seconds, 15 seconds, and then he would just say "yes". And then you'd wait a week or two and he'd make it. He'd put together whatever I wanted.

It was he [3] who in the end said "it's no use having a whole lot of these sequencers and specialist gear to control these massive pieces of equipment—what you need is a computer, because it's the ultimate controller". And so with a computer, of course, you had a mega-sequencer.

Were you aware of anyone else doing things like that at the time? You must have felt rather isolated.

Well, I don't think there was anybody else. I mean, I did then meet up with Max Mathews at Bell Labs and he was doing something quite similar. But he didn't quite have the…he had slightly older equipment, and he was trying to make a music system called GROOVE [4]. But his computers were rather more old-fashioned. And they suffered at Bell Labs from something that I think a lot of institutions do: it takes a long time to, for instance, buy the stuff, to make the stuff, so there's a big time lag. Whereas I was able to say to

David “go and buy whatever you want and make it”. And so he could produce things in a few weeks.

So your independence was an asset in that way.

Oh terrifically, yes. I mean, I think that sort of time delay, of having to go to someone else for an audit, and persuade them that this is important, and then going to a buyer who has to search around for the best price. And by the time that happens there’s always a delay.

And it’s already out of date by then.

And it’s out of date, yes. And that was really the trouble with Bell Labs, and that’s why I think—not only because Max Mathews got old—it became a bit of a juggernaut and couldn't go ahead. It’s a great shame because it was the only like-minded place to me, I think.

Once David Cockerell had suggested a computer to you, it wasn’t then a question of nipping down to the shops to buy one.

No, well there was only one—the only sort which could possibly fit was a Digital Equipment [Corporation] PDP-8, which was a new generation of transistor process control computers. It had very little power—it had 4K of memory—and was very slow. And it cost a bomb. It cost £4000 in those days. And the extra 4K of memory which we got also cost £4000 so we made 8K of memory in total. Which is less than anything you can get now.

And your wife sold her tiara to help finance this.

Well that’s a good story, yes. We sold the tiara for £4000. It was a ridiculous thing, made of pearls and things, and it could come into brooches. And she wasn’t the sort of person who would wear it anyway. It was just sitting, waiting to be robbed in our house. So we sold that for £4000, and in fact that exactly matched the cost of a computer, so it was a really good bargain.

From that point on did the computer really change the way you worked, and did it do the sort of things you were expecting it to do?

Yeah, completely changed, because once you had something that could control equipment, then you could build rather elaborate equipment, so the next thing that David built was an oscillator bank of 384 [5] oscillators. So instead of five chunky boxes, I suddenly had 384 oscillators, each with their own voltage control, and it was only a small box that contained all that. And it could be controlled directly by the computer. So the computer didn't—like modern computers do—have to do very much. It didn't actually have to produce sound, and it didn't have to work out very much, or the things that it had to work out, it could do beforehand. And then all it had to do was to send signals in succession to different bits of equipment. And so if it could do that several thousand times a second, that was rather like cutting a thousand slices a second of a tape, say.

The computer was used, then, as a sequencer, as a controller for the analogue sound-producing equipment.

Yes, and digital sound-producing equipment, because it didn't really make any difference from the computer's point of view whether it was sending a signal to tell a digital oscillator to come on or an analogue oscillator. So gradually the equipment became digital rather than analogue.

That change took place over a long time.

Oh, it took some years. I'm so vague about this—it's such a long time ago. The whole thing must have gone on for 15 years, and each year was a gigantic step ahead of the last year.

For a short while you worked at your studio with Brian Hodgson and Delia Derbyshire—moonlighting from the BBC Radiophonic Workshop—as Unit Delta Plus.

Well that was a sort of transition before David Cockerell, or perhaps it was just at the time when I'd met David Cockerell. At any rate we

hadn't formed EMS by then. Brian and Delia had heard about what I was doing and they thought that I'd be very good at joining up with them to make an independent company to make jingles, to sell jingles to commercial companies for advertising. That was our aim. I didn't fit in with that philosophy at all, because I kept wanting to do more elaborate things and have more control over the equipment. And they really wanted to make money. So we did one or two jingles, one for Philips and perhaps one for IBM. Then we gradually drifted apart.

Do you have any recollections of working with Brian and Delia?

Well I didn't really work with Brian at all; he was a sort of business side of it, so he didn't do any electronics or music, but with Delia, yeah the first concert which we gave at the Queen Elizabeth Hall [6], she was my sort of assistant, coming on and turning the machine on, but not very much, she wasn't involved very much. I think she was already getting away from it.

Unit Delta Plus didn't last very long but shortly after that there was the celebrated Queen Elizabeth Hall concert where you played the *Partita for Unattended Computer*.

Well, that's the one I'm thinking of because on the footage of that there's Delia on the stage. I didn't realize that until I saw it a few weeks ago again, but anyway it's Delia coming onstage to switch the computer on.

Do you have any recollections of that event?—presumably it was quite nerve- wracking to have a computer onstage in 1968.

Was it 1968? Well, just after that that there was an exhibition in London called *Cybernetic Serendipity* [7] where I had the computer on exhibit and people would whistle to it and it would whistle back and make variations on your whistle, and it would anticipate one or two tunes. So I'd already made it sort of mobile. And of course it was nerve-wracking. It was always nerve-wracking in the Queen Elizabeth Hall. The very idea for the guards that there was a

loudspeaker attached by wires: they already had the fire extinguishers out, you know… It was terrible working there. But it's all different now—you see people putting loudspeakers on and taping wire to the ground, but in those days this wasn't done at all.

What was the response to such events?

They were marvellous. I mean the Queen Elizabeth Hall—I think we put five concerts on, one each year, and each time it was full to overflowing, turning people away. It was extraordinary, really. And that was…I think the Queen Elizabeth Hall holds 1100 people [8] so it was amazing, the first electronic music concert in Britain was well oversubscribed.

Do you think people went just out of curiosity? Did you market it heavily?

Well it was the first electronic music concert, so I suppose it was curiosity, and then as electronic music became more familiar to people we put on the other concerts. We put on famous pieces like Stockhausen and so on. You know, we had a draw of well-known things as well. And then we had very good…we did have all the children running around the Underground sticking things on windows. But I think there was genuine interest in those days.

Your computer music studio was quite expensive to maintain, and that's one of the reasons you set up EMS: to produce and sell smaller synthesizers to pay for the studio. How did you get to know Tristram Cary, and how did EMS start?

Well, I can't really remember how Tristram…we formed a company called EMS and that must have happened at some stage, and there were three of us. I made Tristram and David Cockerell directors of this company EMS and I think we must have brought Tristram in to give us advice on making a commercial product. So all three of us then designed the VCS3. He designed the box, I designed the spec. and David designed the hardware. And that was the first one. The spec. was to make it cheap enough for lots of people to buy, although it was very expensive by today's standards, I mean it was

£330, which I suppose is about £4000 now, which would be incredibly expensive for a synthesizer—about what the new VCS3s are going to cost anyway…(laughs) but that's only because they have antique value, as it were.

What do you make of the current fetishism for early analogue synthesizers, and the exorbitant prices they command on eBay?

I've got a Synthi A that I'm longing to sell, so I think it's a very good thing![9] I'm now doing a lot of electronic music, but entirely by computer and it's so amazing, what you can do, that I just don't believe when people say "well you can get these wonderful sounds from these analogue synthesizers".

I gave a lecture the other day [10] and there was some expert [11]—I took a Synthi A along and there was an expert, a professor of something at Cologne, and he was able to give the most dazzling demonstration with this. But on the other hand, you get very good software simulations of it and…what do you think of it?

(laughs) I think it's like collecting vintage cars or something—they're of their time and they do certain things well, and have style, but they need a lot of maintenance and the prices are ridiculous.

I think it's identical to old cars, you know, liking the polish of the seats and the smell of leather or something but here you have the old hardboard and broken pins of a VCS3— it's completely daft.

The smell of the hot solder, the smell of the hot circuit boards…

Yeah, I must say I do, sometimes, if an electric plug or something goes wrong, and you get this smell—it does remind me of the old days. That terrible smell of burning— expensive burning!

I think that one of the things that people do like about those old synthesizers is simply the human interface; the way you actually interact with the knobs and the controls. That's part of it, I think.

I suppose so, but then you do interact…I'm doing a very exciting piece [12] at the moment with a violinist, and all the orchestrations, as it were, are made out of sounds which she plays and then she plays solo above them. Now the sort of tiny, wonderful manipulations which I can do with her sounds are to me exactly the same as twisting those knobs, but I can do it in a much subtler and sort of cleverer way, I think, with the computer.

Well it's good to hear that you're doing some music—I guess there was something of a gap when you didn't do much composing.

No, it's an amazing new streak. I mean, a year ago I got a commission to do a 40- minute piece [13] for a sculpture [14] which has got hundreds of loudspeakers and it's going to be in Istanbul in May, actually, because it's European Capital of Culture. And so I got this commission, which was the biggest commission I've ever had. And since then, I've learned all the new programs and I'm very, very keen on it again.

Which programs have you been working with?

Max. I like Max very much. And Adobe Audition for manipulation—a very nice program for breaking up sounds. And then really it doesn't matter what sort of workstation you use, because they're all roughly the same. But I'm not using any synthesizers as such, so it's all sampled sound, manipulated sampled sound.

And that's exactly what you started out trying to do with your computer studio in the first place wasn't it? Effectively sampling—as we'd now say— acoustic sounds and then manipulating them in the computer rather than doing tape manipulation.

You're quite right, yes. That's exactly what I was trying to do, but in those days it was so frustrating because you couldn't sample very much sound because of the memory it took. And you certainly couldn't, with early computers, manipulate it. I mean, you couldn't say "add reverberation" for instance—that would be an incredibly demanding feat for a computer to do in those days, so you'd have to

use a plate reverb or a spring reverb or whatever it was. Whereas now, with our computers, it's really easy and there are very good programs to do things—plug-ins to do reverberation and filtering and whatever you like.

And then part of this commission I've had—it's actually a result of that film, *What The Future Sounded Like* [15]. At the end of it I make a plea to find somebody to work with, and then York University, who control this sculpture from York University in England, although it's been in Seville and now it's going to Istanbul, the whole control of the sound structure is done from York. It's a gigantic sculpture, you know, the size of a house and with 150 loudspeakers of very good quality so it's spatially extraordinary what one can do. Anyway, they've also been building me these very nice little programs: they've built a wonderful filter bank for me with several thousand filters which are easily controlled from the screen, you know, things like that. So it's been incredibly luxurious this last year.

This is the realization of the sort of things you must have had in your head 40 or 50 years ago, then.

It is. I mean it's an incredible stroke of luck. It's lucky for me that I'm able to do it, because I'm 77, and that I'm still keen, and that there are people who are prepared to...like doing it with me. Like this young violinist, who's been at music school since she was four years old. So she thinks that we're making marvellous sounds that have never been heard before. So it's wonderful.

Presumably it was the resurgence of interest in your older work that has led to this new interest in it.

I think it is, yes. I mean it's a fact that any interest is so easily distributed on the internet, so it's a combination of both; that it is quite interesting, and that people are able to discuss it. There's also the fact that it wasn't really very well known, for some reason. It was sort of ignored in America. Although it must have contributed quite a lot because David Cockerell, and Jim Lawson and then Peter Eastty, who all worked for me, were stolen by Boulez to work at IRCAM, which was one of the big contributions to the end of EMS.

So word must have got around.

Well, the engineers and the programmers were well known, so they went to found and start this fantastic electronic music institution in Paris. So in a way, the work continued.

It must be quite rewarding to see things like Harrison Birtwistle's *Chronometer* being re-released on CD [16] **now. What are your recollections of working on that piece?**

Well that was terrific. It's quite funny because suddenly I got this telephone call as if I didn't exist, about "how incredible—we've found *Chronometer*!", But I had it all the time! I mean, Harry knows perfectly well where I live, and we meet, and that sort of thing. But it's marvellous, the CD/DVD because on one side it's surround sound, so the DVD side is for 5 channels, and then the reverse side is a straight stereo CD.

And it was conceived for 8 channels, I think?

Well, I had an 8-track Studer [17], and I'm sure I filled up all the tracks. So it wasn't so much it was conceived like that because ultimately… when we put it on at the Queen Elizabeth Hall it was played on an Ampex 4-track. So it was originally 4-track when it was first performed.

What did Birtwistle present you with to work from? That's something that's always puzzled me about the piece.

Well, it wasn't really like that at all. What happened was that we decided to make a piece using clock sounds. And then we decided to use various clocks like Big Ben, and Harry was very good at getting permission so we could go up the top of Big Ben. And we made a huge lot of tape recordings with contact microphones and air microphones. Then Harry made a plan, on Sellotaped pieces of paper—say about 8 feet by A4, Sellotaped together—and drew a composition on it, with just a sort of flow diagram, really. And from that I sort of got the sounds together and every so often we'd meet

and he'd say "I like this" or "I like that" and "let's put this here". And so we built it up in that way.

It was a collaboration.

It was entirely collaborative, yes. He didn't touch any of the equipment or have anything to do with the production of the sounds, but he'd say things like "can we have it harsher", or "harder" or "what about having it very repetitive for a bit?" Things like that. Very inspirational things as to how it would sound in the end.

One of the things that's particularly significant about that piece is that the manipulations of the clock recordings—the speeding up, the slowing down—were all done in the computer rather than on tape. For 1972 that was quite a breakthrough.

Yes, it was marvellous, because it's quite a long piece, 25 minutes and—I might be lying about this—but in my mind, all that one had to do was to start the program off, and everything—including the stopping and starting of the tape recorders and everything— was done under computer control from beginning to end. By that time I think we had digital tape and so the tapes would stuff the new material in and so on. So it was technically a very difficult thing to have done. I mean it was terribly difficult; everything was working at its peak. But that was my ambition, for it to continue unaided, and to have everything, all the control, be done in the computer.

Do you think people realized what was going on at the time?

No. Certainly not, no. And also there's this sort of magic thing of saying "it's done by computer". It's like saying "he's got it up his sleeve" to a magician. The computer doesn't do anything without a huge lot of hard work. Especially in those days, where it was all machine language and terribly difficult, tricky programming which always went wrong until you did it the thousandth time, and that sort of thing. So it was lots and lots of graft.

And you were pushing the memory and capabilities of the computers to their maximum, as well…

Absolutely. Always. It was always on the limit. And in fact everything at EMS was always on the limit. Money was always on the limit, and we never got any finance. And I never charged people to work in it. So people like [Hans Werner] Henze, or Harry, or anybody, actually. All the people who worked there didn't pay any money to it.

I think you gave various seminars and so on to various SPNM [18] people, and a number of composers came to those. You also eventually wrote a letter to *The Times* offering your studio to the country.

Yes you're right. But nothing came of it. Well, the only thing that did come of it in the end was that when EMS finally could no longer could cope and would have to go into liquidation—and there were a whole lot of things that contributed to that—then the National Theatre did agree to take it over. But they didn't take it over in a rational way at all. I mean, for instance they didn't want me to explain what the wiring was, so I know that somebody just came with huge wirecutters and cut every bit of equipment off from where it was. So there was a jigsaw which could never really be put together again.

I mean there were thousands of wires behind the computers. I don't know whether you've seen the rather pretty pictures of the studio, with the polished floor…well behind those racks there are really millions of wires, I mean all wired by me, but millions. Huge great cables. A nightmare. So once you cut those up you couldn't possibly put them together again

It was just dumped into a storeroom, wasn't it?

That's right. I think what happened was…Lord Astor, who was a director at the National Theatre, thought that he was going to get money so they took the stuff away and then I think the money wasn't forthcoming. So it was put in a storeroom in a basement, and rained on, actually. Terrible.

It's a sad story. What strikes me about EMS is that it was very open…more like a salon than a showroom or a business. And you were prepared to offer your facilities to composers and eventually to a good home.

Well the thing about composers was in a way, perhaps, rather selfish because what I wanted was exciting new musical projects. So it wasn't just anybody who could come and work there—they had to say "this is what I'd like to do". And then if it struck me as furthering what needed to be done in electronic music I'd jump at it. Jonathan Harvey came and had some very, very complicated things he wanted to do. I don't think we ever actually achieved it, although when I meet him now he's rather nice about it. But he wanted very careful multi-oscillator juxtapositions and it seemed very interesting, but I think it was slightly beyond what we could actually physically do.

You said that one of the things that shows off the studio to best advantage is Henze's *Tristan*. How did that come about, and why would you say it shows it off particularly well?

Well it's a marvellous piece. A piano concerto with orchestra, really. And the electronic parts are very important. I was allowed complete free rein to roughly do what I wanted. Although Henze was able to get marvellous musicians together and we could record wonderful things like the piano being hit and beaten, and other instruments being distorted. I mean rather like what I'm doing now, in a way.

This was when we had this video camera recording sounds. That was an interesting idea. We had a Sony colour camera and David extracted numbers from the digital output of the camera [19]. So once you had these numbers you could assign them, logically or randomly, to, say, oscillators and amplifiers. So wherever you point a camera you're going to get a different sound out because it depends on the colours and the density of the colours in whatever position the camera is looking.

So you're mapping what the camera sees to various sonic parameters.

Yes, and it could be arbitrary. It doesn't really matter. But you get a sound out which is a different sound according to where the camera is pointed. So at that point you can say "I prefer this sound" or that sound, depending on where you point the camera. So if a camera is pointing at a poppy, you could say "I much prefer the sound of a poppy than I do of a sunflower", which has got more yellow. Anyway —with a clever combination of what sort of sounds were going to be produced: I loved making huge chords that would sway and swoop and whatever it was. You pointed the camera in different directions and people would go completely ecstatic. They'd start pointing at blades of grass and hear these swoony sounds come out and think that they were the most marvellous composers. And I'd quite like to do that now. It'd be fun, wouldn't it?

And we're talking the mid-70s here, so that's a pretty advanced use of the technology of the day.

Yeah, I don't think anyone else had done it then.

Have any recordings of that survived?

Well, I suppose they must have. The trouble is that they're probably on half-inch tape, and that means dubbing them down, and they'd be pretty noisy. The trouble with those days was that you thought the next day, every next day, every tomorrow, was going to make a nicer sound. And tape was rather expensive, so everything got overwritten, you know. Even though the next day sounds were never as good as the previous days, which actually usually happened anyway.

You'd already gone over the tape.

Yeah. I find this now. I find that it's too easy to obliterate yesterday in the search of tomorrow…so I'm now more cautious and I keep previous examples much more.

Do you think in some ways it's now become too easy to make electronic music?

Well I think it's become very easy to make run-of-the-mill electronic music using synthesizers and what's called computer music, or

electronic music, using computers. I think that is rather easy, and there are defined techniques. If you look at electronic music magazines or electronic music journals, they tell you what you've got to do— you've got to punch in this here and here, you've got to click the rhythm there or whatever it is, and it seems to me that not very many people are using *musique concrète* in the sort of way in which I am still. I mean, I think *musique concrète* was always more interesting than electronic music. And it was always so. Pierre Schaeffer in Paris knew that the texture of a recorded sound, of a natural sound, had much more interesting things on its analysis than any mathematically-defined sound such as Stockhausen ones.

Did Stockhausen work at your Putney studio?

No. He didn't. I think that's a rumour which has come about. He did come perhaps once or twice. He certainly came once and fiddled around with a number of pins on the Synthi 100. And he was already a sort of demigod, so everyone gasped. But no. Nothing came out of it. I mean he must have been quite impressed with it [20], but then he had the Cologne studio anyway.

So what you were always after was the manipulation of found sounds or real world sounds more than generating them electronically.

Yes, so I think things like the Henze, and *Chronometer* are much more like what I really wanted to do.

And the new technology is now allowing you to get closer to that.

Exactly. Now I can have…well, it doesn't matter how many terabytes of data. I mean, I've got 20 one-terabyte discs—a formidable amount of material.

It's a bit more than 4K…

It's a bit more than 4K. But it's so much more than 4K, isn't it? That's partly because it's all backed up, but still, space is just not a problem. And then for instance, the other day I found, recording with this girl, that…I've got a nice Canon Ixus camera. And I put it

on a tripod and recorded her. And the quality of the video recordings and of the sound recordings is completely amazing. And we tried it out with six or seven different microphones, and the microphone on this tiny little pocket camera is completely staggering. You can take out any of the internal camera noise—you can just subtract that from the waveform and it's completely pure. Now there's a good discovery—only made that last Thursday!

What are your thoughts on the current state of electronic music and the way things might go?

I don't know. I've got no idea. Have you heard of the Red Bull Music Academy? They go to a different capital city or city round the world each year and they spend millions of pounds establishing the most incredible studios and auditoria and lecture halls and beautiful local artwork. And this is all not really for advertising, but just because Red Bull has got a music-loving director.

Anyway, I gave a lecture there and they asked exactly the same sort of questions: "what's the future?" and so on. So my answer was that it's up to them. I don't know what the state is, if there is such a thing as a state…it's difficult to know until people…there must be millions of people working around in private ways like I am. But…perhaps you could ask people to contact me!

Presumably one thing that's changed an awful lot is that you don't feel like you're working in isolation in the same way, partly because of the internet.

Yes, and partly because of working with other people. And the other thing is that money…because computers are so terribly cheap, you can't not have a computer, whereas in EMS days it was terribly expensive to maintain everything. It needed all these people and it needed bits of equipment all the time. It was hugely expensive to run. So even by selling all these synthesizers, at the end of the day you had to pay the factory and the factory people and whatever it was. There was very little money left and so we tried to go more and more public in America and sell more and more and get more and more commissions for instruments. And that was our downfall.

[1] Trevor Pinch and Frank Trocco , *Analog Days: The Invention and Impact of the Moog Synthesizer* Harvard University Press 2002.
[2] Mark Dowson.
[3] Other accounts suggest it was Mark Dowson who first proposed that Zinovieff should use a computer for complex sequencing.
[4] GROOVE (*Generated Real-time Output Operations on Voltage-controlled Equipment)* was developed in 1970.
[5] In contemporary accounts, the oscillator count is put at 252.
[6] Zinovieff is not, in fact, describing a Unit Delta Plus concert, but the one mentioned later including the *Partita for Unattended Computer*, which took place on January 15 1968.
[7] This was an exhibition of computer art at the Institute of Contemporary Arts that ran from 2 August to 20 October 1968.
[8] In 1968, 1103; now 915.
[9] Zinovieff's Synthi A was auctioned in May 2011 for £6050.
[10] At the Red Bull Academy. See http://www.redbullmusicacademy.com/ lectures/dr- peter-zinovieff-the-original-tectonic-sounds (http:// www.redbullmusicacademy.com/lectures/dr-peter-zinovieff-the-original-tectonic-sounds)
[11] Jono Podmore, aka Kumo, Professor of the Practice of Popular Music at Musikhochschule Köln.
[12] *OUR*, with Aisha Orazbayeva. Released on Nonclassical NONCLSS013.
[13] *Bridges from Somewhere and Another to Somewhere Else*.
[14] *The Morning Line* by Matthew Ritchie.
[15] A 2007 documentary on EMS, directed by Matthew Bate.
[16] *Recovery/Discovery: 40 Years Of Surround Electronic Music In The UK*, Sound and Music SAM 0801.
[17] At the time 'Chronometer' was being realised, EMS had two Ampex AG-440B four- track recorders, which could be synchronised. An 8–track 3M machine, with Studio Techniques electronics, was acquired later.
[18] The Society for the Promotion of New Music, since 2009 part of Sound and Music. [19] David Cockerell and Richard Monkhouse have pointed out that Zinovieff is, in fact, remembering 'Show-me' the video digitiser built by Monkhouse incorporating a graphics display built by Peter Eastty and software by Jim Lawson.
[20] The electronic music for Stockhausen's *Sirius* was realised on an EMS Synthi 100 at the studios of WDR Cologne between 1975 and 1977.