

**Interview: Brian Cooper****24 September 1997**

The following is an edited transcript of the interview done with Mr Brian Cooper at the CSIRO division of Radiophysics in mid-1997, following a lunchtime presentation by the Melbourne CSIRAC history team. This version has been edited for reasons of clarity, but adheres to the tone & general form of the original digital tape. Certain hesitations, repetitions, interruptions and points of difficulty have been omitted. Where it was felt the speaker could benefit from some re-expressive licence, this has been done.

BC	Brian Cooper
TH	Terry Holden
DL	Dominic Lowe
DM	Doug McCann
SP	Steve Pass
AB	Alan Bromley

SP We're rolling!

AB Name, rank serial number.

[general laughter]

SP The work you were doing before CSIRAC; what was that really?

BC Oh well, Taffy Bowen was very much interested in cloud physics. This was in the early years of it. Apart from promoting artificial rain, he wanted some measurements done on the physics of rain formation, and one thing I worked on was an instrument to go up in a meteorological balloon. It had a little microphone mounted underneath, which would (according to the strength of the impact) measure the size of the raindrops and get their distribution, so as to find out how the drops grew as they came down through the cloud. That was my main preoccupation with him. I'm not a physicist, I was just working on the engineering aspect of it. It got some results...Maston and Trevor were hard at work on the electronics of the CSIRAC at that stage, and Trevor thought a permanent storage would be a good thing to have. So he roped me in to change over, and do this little drum ...that's how that happened.

SP Did you hear about CSIRAC before any of this?

BC Well, it was always up there in the top floor next to the library, gradually growing, racks spreading out across the floor. I didn't know the real impact of electronic computing till I got really involved in it.

DL Do you remember which side of the corridor it was on?

BC I think I'm right in this; there was a big room at the National Standards Library (we occupied one third of that building approximately). There was a set of double doors leading through to Radiophysics. There was an office for the computer people, and next to that was a double length office in which the CSIRAC grew. I think that's the approximate geography of it, up on the top floor.

SP What was your first impression when you met Trevor Pearcey? How did he strike you?

BC An academic style of addressing you ... just a fair, average scientific guy.

SP And Maston Beard?

BC Oh we'd had a fair bit of contact with Maston from radar work. If you're thinking of possible personality conflicts, I don't think there were any.

[general laughter]

SP So Trevor was going around asking for somebody to make a drum?

BC Yes.

SP And you put your hand up?

BC Well, I don't know if I put my hand up or whether I was press-ganged into it, I can't remember now. Anyway, I wasn't really absorbed in this cloud physics operation, so I was glad to change over to pure engineering.

SP Did Trevor gave you the idea for a drum, or did you work it out?

BC Well, he may have referred me to the papers by Booth. There were a reasonable number of papers already appearing in the journals on the principles of magnetic storage, so it was a matter of experimenting with the materials you could use. I remember there was some possibility of using nickel plating; nickel was sort of magnetic, and would form a nice thin plating, but I guess the proximity of the metal base would have spread out the flux. I think maybe we found we couldn't get the density of bits per inch that you could get with a custom-designed magnetic oxide coating. I suppose things were moving rapidly because of the demand for magnetic tape, which was better than the old magnetic wire recorders.

SP So you looked around for the paint?

BC Yes, I don't know how we would've found out about the supplier. It was some English company – I seem to remember their name was Thermionics Products Limited. Obviously they were into the tape recording business primarily.

SP Did you spray it a few times, or just once?

- BC We probably had to experiment quite a bit. The spray painter downstairs was used to spraying paint. I suppose he did a pretty good job... it was pretty much like an ordinary paint lacquer.
- SP How did you come about using the gyroscope motor?
- BC During the war we did airborne radar work. We somehow collected instruments from the RAAF planes, and there might have been a little gyroscope sitting round...with nothing to do. We could have used conventional induction motors, though small ones are designed for 1500-3000 revs, whereas this one would spin 6-7000 revs, I think, and reduce your access time.
- SP How many versions of the drum did you make?
- BC We got that one working, and I remember Trevor saying 'Could you quadruple the storage capacity?'. I don't think it got very far, but they machined up a drum about twice the diameter and twice the length, I suppose, driven by a belt drive, which would've quadrupled the capacity, but never got off the ground. Then I suppose things were quiescent for a while. I don't know how long it was before someone built that disk. We preferred a drum because of the problem with the pitch changing... as in the microgroove record, the forms are dictated by the smallest radius.
- SP So the drum that you first made, the one that's in the photographs... that was actually used on the machine?
- BC Oh yes.
- SP Running for a while?
- BC Yes.
- TH When it got to Melbourne, it had the disk, didn't it?
- BC It could have. I can't pronounce exactly on that.
- AB As far as I recall, the disk was machined in Sydney. Then when it was taken to Melbourne to be coated, it was found to be not completely true. The aluminium had relaxed a bit and it had to be re-machined there.
- DM Can I ask you if you ever write a program for CSIRAC yourself?
- BC Oh, only amateur... It had a pretty simple instruction set. I remember thinking 'Oh, I could get it to factorise the integers from one to umpteen...'. I had it printing out 2 is to 2 times 4 and so on, and finding out the prime numbers amongst them. That was a hobby, it wasn't any practical use. Not like finding the 127th millionth mersenne prime. Well, it's not that far yet, but the numbers are well over 100 millions, 2 to the 1 million something-or-other...

- DL Did you have any sense of where this computer idea might be going? Did you have any intuition?
- BC No, no, it was just... 'not my department, said Werner Von Braun'. It was something to work on, and I assumed the people who wanted to use it had something useful to do with it. No, I never got involved in the political committee decisions much at all.
- DL I meant that this was a fundamentally new kind of machine, that would go on...
- BC Well, I suppose in terms of time scale, putting the stored program idea into practice was still pretty new, wasn't it? Trevor was pretty smart in picking it up and deciding how to formulate the machine structure.
- DM Can I ask you about Edward Bowen? He was obviously a key person in encouraging the whole program to get going, but also cut it. Did you have much interaction with him?
- BC No, as far as I remember he just gave Trevor a free hand. I never saw him coming round much, asking what did what. I think he was preoccupied partly with going to England to organize the Parkes telescope, which was all in the early stages then, and getting ideas for what sort of structure would be best for that. He was really absorbed in the cloud physics, and trying to establish whether artificial rain-making was practical for the country areas.
- TH I don't know whether this is in order, but what's your background, and what was your designation in radio physics?
- BC I went through engineering at Sydney University and finished up in 1940. At that stage John Madsen – Sir John Madsen now – was grabbing all the engineers he could find to go and work on radars. There were only 50 graduates in engineering at that stage, about equally divided between mechanical and electrical, and several in aeronautical and chemical engineering. So there were about 10 or 12 of us, although I think a couple might have escaped to industry. We were actually press-ganged over to radio Physics before we'd done our final examinations.
- TH This was electrical engineering.
- BC Yes. And so I spent the next few years working on various aspects of radar.
- TH And you were a research scientist?
- BC Yes, I was classed as... they were called 'Research Officers'
- TH That's right! So we were, so we were.
- BC You... when...?
- TH I was a research officer in building research from 1944 on. Not much use to your tape, but still, never mind. I think you asked at one stage, Dominic, whether there

was any sort of feeling of class in the division. That is, were the experimental officers a lesser breed than the research officers?

BC Oh well, I suppose we were all aware of each other's limitations. But a lot of the lab craftsmen down there made it upstairs over a period of time, once they proved their capability.

TH So it was a meritocracy?

BC Yes.

TH And there was a camaraderie?

BC I think so, yes.

DM You mostly would have been fairly young workers there at that stage?

BC Yeah, well everyone was pretty young in those days, there was a young atmosphere around the place... perhaps a bit of frivolity at times –

[BC & TH laugh]

DM During the period when you were working on the drum, the computer was rebuilt, wasn't it?

BC Oh...well, I don't know and can't say when it was properly working ...you see some simple thing would break down every so often ...it was a long time before you could say it actually produced a useful output, I suppose.

DM Did any of the early engineering work leave a bit to be desired? Was it a bit too improvised, that sort of thing?

BC Individuals had different capabilities, I suppose. I think I mentioned to you the other day (without denigrating him) Frank Tonkin, who was an experimental officer. Often with the tolerance on some circuit, you've got to tweak it so it just works, and then after a week or two it would need tweaking again. You see, there's an aspect of high-tolerance electronics which has to be there to make things work for a long period of time. So that's just one off-the-cuff remark...

TH I understood from what Alan said earlier today that the first engineering was not by Maston. You said something about Maston taking over and rebuilding the machine, or re-engineering...

AB No, Maston re-engineered Maston. I think.

BC Mmm. Well, I'm not sure about that. I presume Trevor said 'We want the thing to go like this... I've got the idea of having a program counter, and an electronic store, and we want a thing to go through the sequence of updating a program counter, taking the present word out of store, operating arithmetic permutations on it, then putting it

back, updating the program, going on with the next, and so on -' ... and this great idea of being able to take an instruction in numerically coded form and operate on it too and put it back. That was the big thing that made the thing so flexible.

DM Can I ask you about Jack Palmer, and what sort of work he did?

BC He was an experimental officer, and he didn't have any formal university training. I can't say whether he actually went to tech, but he was an empiricist who put things together and fiddled until they worked.

DM And he worked on the coils for the drum?

BC No, on some particular part of the computer. Whether it would be an electronic part, or whether it was the program counter, or part of the arithmetic unit, I don't know now. But that's a minor detail, I think you can forget what I said about that.

AB When did you actually start work on the drum? When were you transferred over to the group?

BC I can't place it... I know the electronics for the computer were well under way, there were lots of racks there. It could have been... 48-49... When d'you think, according to that record you had on the screen in there, the first rudimentary program got going?

DM October or November 49 -

BC Yes, well... be about that stage, yeah.

AB One thing that's always puzzled me is: how did you make the heads for the drum?

BC That was my assistant Jack Palmer. I said we need to get some thin nu-metal, and cut a strip a couple of millimetres wide, bend it round into a U-shape and somehow put the smallest possible air-gap. That would allow some flux to leak out into the magnetic drum surface, and at the same time we wound a few turns of wire round -

AB So you wound the coil first before folding it up?

BC Well, I think so... the thing would be roughly U-shaped... we'd have wound a few turns around and then closed it up and tried to clamp it on probably a thin bit of insulator to specify the gap, and probably poured some resin, whatever resin was usable in those days. There were probably designs in some of the papers, I don't remember how to make a suitable recording head.

AB And how did you judge the distance to float the head off the magnetic surface?

BC Well, the concentricity wasn't perfect, so you had to use a feeler guage. I suppose it was pretty concentric, but... putting a feeler guage at say one thou ... you think: ' Well, that's about as close as we dare go ', and then push the head up against it, lock it down with a set-screw and hope it wasn't going to somehow move and gouge the surface up.

TH Did that happen often?

BC I don't remember.. I think it must have been conservative enough to keep it going. See, the closer you got, the higher the recording quality. The finer the pattern you could generate, the more bits per inch you'd get, but...

TH But you didn't have too many head crashes.

BC No, no... no.

AB Presumably that gyro motor was a d.c. motor?

BC Yes, it was, yes.

AB So that means you didn't have any -

BC It didn't have speed control. It was an asynchronous system. One of the tracks was used to provide a clock pulse and it didn't matter much whether the speed varied a bit, we just dumped the output into a static store to be read out into the computer as available.

AB Because I remember there was a gap in the timing track...

BC Yes, yes.

AB Your responsibility included the statusizer and the interface?

BC Probably, yes, I think so.

AB One of the questions which came up in Melbourne was the curious note that it was a serial machine, but the arrangement of the heads on the drum made it parallel -

BC Parallel, yes.

AB But it certainly wasn't practical to consider synchronising the drum with the timing chain inside the computer itself?

BC No... I do remember reading a paper by Williams about position synchronization of a rotating drum. Obviously he wanted to work it that way, but servo techniques weren't terribly well developed then. Williams was a pretty smart man, he probably worked out how to stabilise a rotating drum without it hunting like mad.

SP Why did you choose to encode those index markers as magnetic pulses, rather than hard sector type things?

BC What, you mean a vacuum-tube shift register or something? No, we had to have a permanent store.

- SP No, I mean the index marks on the drum – you probably had a separate track for the counter. Why was that as magnetic pulses, as opposed to cutting slots and making inductive measurement?
- BC Well, I suppose we could have done it that way, but you'd have to have an optical readout. It's much easier to just make it with the same sort of magnetic recording.
- SP So you made a special gizmo to write that on?
- BC Yeah, I suppose so. I guess we got the motor running, and had it coasting up to a pretty stable speed, with a very stable voltage, observing with the frequency counter that the revs per second were getting stable. The gap we left at the end wasn't critical, so we just had to generate a burst of pulses that were equal to one revolution less a little bit. It wasn't critical, so once it was on there it was ok for the rest of the time.
- DM Can I ask you about the laboratory as opposed to the workshop? How much work was done in the workshop, and how much was done in the laboratory itself?
- BC Well, the mechanical work would be in the workshop. Technicians usually worked up in the lab. There was a wiring shop down below. The radio astronomy gear was generally wired up by the people who were going to use it, so it was that sort of tradition. For any vacuum-tube circuit (it was mostly bread-board work anyway) you got a crude chassis and got the prototype circuit more or less going, then had something decent built up after that. Maybe the post-bread-board thing was mostly made up in the workshop...
- DM How many people were assisting you in building those things? You mentioned Jack Palmer and Frank Tonkin. How many others were there?
- BC There was George Fairweather, I remember him being up in the lab, and some other T.O. – I can't remember his name. There were at least those two extra. Reg Ryan, of course, had to have someone put his delay lines together, and I don't know who helped him with that. Don't know if they ever got mercury poisoning...
- [general mirth]
- AB The life expectancy of people from that generation doesn't seem too bad.
- DM Why didn't the work on the second drum get finished? Was that because the disk was developed at that stage?
- BC I don't really remember the circumstances.
- DL Do you remember how you felt when the machine was dismantled?
- BC No, no, I was absorbed in the solid-state transistor electronics by that stage.
- DM You said when you were developing the drum that one thing you tried was to use a sheet of plastic to spray that down...

- BC Yes, one company had plastic with magnetic oxide coating sprayed on it. I think we thought of gluing it on the disk, but obviously it would have been difficult to do that without getting it wrinkled. Nothing like having a precision surface with a very thin coating on it.
- SP Your later work with transistors; what did that consist of?
- BC Yeah, they'd just emerged then... but of course, you wouldn't have been able to build a computer at that stage.
- TH Can you expand on that? You couldn't have built a computer at that stage out of -
- BC Well not of the point-contact transistors. The junction transistor was an idea that came out some time after the point-contact transistor. I don't think you could have made a computer with point-contacts, they were so erratic.
- DM When did they become reliable? Round about the early 1960s?
- BC Well, when the junction transistor was invented.
- TH What year was that?
- BC I've forgotten the year that Shockley published his paper.
- AB I think you're looking at about about 52.
- BC Yes. Mmm.
- AB And not getting any supply till 54 -
- BC I remember Taffy was always in close contact with his old mates at Bell Labs and MIT, and came back with a sample, which was an amazing thing to have. It worked with micro-power, and had a junction transistor.
- SP Were you were working on developing the transistor, actually making it there?
- BC Well, we had Lou Davies as the physicist running that. We were growing germanium crystals, and making germanium transistors in the lab.
- SP Do you think that technology could have gone on to actually mass-produce transistors?
- BC Well, it would have needed huge backing to compete with the overseas people. It soon became obvious that this was the thing that was going to boom. Anyone with venture capital anywhere would hop into it.
- DM Did you have any interaction with the users of CSIRAC, any of the people from Radiophysics?

- BC Oh, they'd be talking over a cup of tea, but I didn't follow their programs closely.
- SP Do you remember some of those early users' names?
- BC No, no. Look, Trevor did a fair bit of program writing himself. He'd write fourier transforms, and work out crystal structure...
- AB The whole thing was experimental.
- BC Yes, I think so. As someone was saying, everyone out there elsewhere in the country wanted to build their own computer according to their own ideas. The idea of a prototype being put into mass production was a long way off.
- TH I remember reading about the early computers and thinking 'Oh, that's all moonshine, making valves actually do calculation, it's too unreliable, it'll never work, you know...'
- BC Mmm.
- TH And then within a blink of an eyelid here I was hearing about one that actually worked and using it! That period of time seems to me to have been... in my memory, fairly short.
- BC Yes.
- AB Do you have clear feelings of the reliability of the technology?
- BC Well, we were working with consumer-type valves, and I presume if someone had decided it was worth making high-quality valves it would have been a lot more reliable. But making high-quality valves pumped out to the last degree of vacuum, with no softness or anything would've cost a lot of money, and the question is: Would it have been worth it to anyone?
- AB By the mid 50s, there were some special product lines -
- BC Yes, there was a project for high-reliability valves somewhere I think, I don't know where the demand was.
- AB The valves weren't the only unreliable element though, were they?
- BC No, I remember the resistors were. I don't know why they couldn't make decent resistors then. They'd usually creep out of their tolerance range, a lot of them, after a while. It was just another aspect of reliability. Reliability engineering didn't really get going till the space program.
- AB I remember somebody telling me about an undergraduate exercise they used to do with resistors. You take a selection and you plot their values, and you fill up the whole plus-or-minus 20% band, and then as the years go on they get peakier and narrower,

and eventually it's a sort of little spike at around the preferred value. What about capacitors at that stage?

BC Well, they were a bit crumby. The electrolytics would dry up and the paper ones would be intolerant of humidity.

TH They'd boil.

AB And the mica ones were only small values, were they?

BC Yes. Yes, the micas were expensive and limited to small capacitance. I remember the airborne air warning radar... once they took it in the tropics it wouldn't last 5 minutes, and they ended up using heaters to keep everything hot and dry, permanently.

AB There seems to have been a systematic avoidance of plugs and sockets in CSIR.

BC Yeah, contact reliability was horrible.

AB So it was hard-wired for very deliberate reasons, then?

BC Yes.

DL Did it occur to anyone else to use some different method, some different morphology in making the drum, or anything like that?

BC I think you had the option of a disk or a drum, there wasn't much else. Obviously the disk took over because it's more compact, same as the flat recording took over from Edison disk.

TH We had a drum on a Control Data 3600 until about 1970, I think –

BC Oh yes, yes. Mmm.

TH High speed swapping drum...

BC How long did you have that?

TH Until 19... from 64 to about 70 –

BC Mmm. Remember the capacity of it?

TH The first disks we got were a hundred or 2 hundred megs, I think, so that the drum was probably 50 megs or so.

BC Yes. Still...pretty big capacity, though.

TH Well, I remember when we got half-gigabyte disks on the 7600 what marvellous things they were. They were the washing machines, you know...

- BC Yes.
- TH – as big as a washing machine, half megabyte. That was state of the art. That was... what, late 70s, early 80s or something.
- BC Yes.
- AB The first disk we had in Basser was on a PDP-8, and it was 8K by 12 bits. And there was no head-retract facility; every time you powered her off, your head would crash – and it was designed for a life cycle of 12 head-crashes.
- BC Oh!
- AB So the machine had to be left powered on all the time.
- BC What happened after a head-crash? Did you polish the surface up...?
- AB Just a bit, yeah.
- DM Can I ask you about Joe Pausey's role in actually running the program? How did he interact with Bowen?
- BC Oh well, he was purely concerned with Radio-Astronomy. I think he'd take a friendly look in the door at the computer, but he didn't have anything to do with it. In the war, of course, he had a fair bit of input into radar techniques, but once radio-astronomy took off, all he was interested in was the bit of electronics that would do the job. I don't know whether he was actually responsible for any ideas in electronics or techniques in radio-astronomy.
- DM If Pearcey ran into a problem, who did he usually discuss it with, or go to at a senior level?
- BC You mean an electronic or technical problem?
- DM Yeah, yeah.
- BC Oh, I don't know... maybe he spoke to the whizzes in the university at elec. eng. from time to time... but I don't think there were any severe problems that we couldn't fix up ourselves...
- AB Did you have morning teas?
- BC Beg your pardon?
- AB Did you have morning tea as a group, or as part of the whole –
- BC Oh yes – but you mean as in solving problems over morning tea time? I suppose a fair bit of that went on, yes.

- AB And there was the canteen in the building, wasn't there?
- BC Canteen, cafeteria, yeah.
- SP The dates of the drum development are set at between 52 and 54. Would you say that's correct?
- BC Oh, it could be before 52. I was never systematic about keeping notebooks, but I think it would be sometime overlapping 1950... 1950 might be the centre of it. I wrote a paper for the Proc. I.R.E; I've forgotten the date on it now.
- SP There's a note here received in 52. So in fact you were working on –
- BC 52...yes well, the work was finished then.
- SP One could say its between 50 and 52, then.
- BC Yeah, yes. After I wrote that paper I don't know what else I did. Maybe I was thinking about the 4-times storage.
- DM So when did you cease work on the drum, on CSIRAC?
- BC Well, it was obviously a few months... when the paper was received... is there a received date there?
- SP Probably the beginning of 53 or something. Received in October, end of October 52.
- BC Yes. Yes, ok. That's about as close as we can put it.
- SP Ok.
- BC I don't know whether these dates are crucial, anyway.
- DM No. There was a period of a little bit over a year when you were actually working on it, is that right?
- BC Oh, it would be over a year, yes... and getting the feel of things for several months.
- SP Alright, I'm done with questions. That's great.
- DL Thanks very much.
- DM Thanks, Brian.
- BC Well ...a few more minutes...
- TH How do you think Maston – you know Maston fairly well, do you?
- BC Yes.

TH Do you think he'd feel comfortable with this sort of questioning, or do you think he'd – ?

BC Well it's a personal matter. Individuals...I don't understand myself why he's become – well frankly, reclusive, but that's the way he is...

TH Did you feel uncomfortable with this?

BC Oh, I admit I'm not very clear-headed...I don't know that I'd even bother about such minor matters. Not as if I'm being interviewed for a big TV program...

AB I think it must be that everyone else feels uncomfortable with you, because everyone else systematically sat on the other side of the room.

BC Yes...suppose that's...

TH Go bite your bum!

[general laughter]

The chairs happened to be placed like this!

BC If you keep working on Maston, you might break him down.

TH I'm going to have a go at him now, yeah.

SP Good Luck.

TH Yeah.