29/3/96

The most likely first program is :-

| | | |
|---|---|---|
| | 1 | −18, C |
| | 2 | −19, C |
| | 3 | Sub 20 |
| | 4 | Test |
| | 5 | Add 21, Cl |
| | 6 | Sub 22 |
| | 7 | c, 24 |
| | 8 | −22, C |
| | 9 | Sub 23 |
| | 10 | c, 20 |
| | 11 | −20, C |
| | 12 | c, 22 |
| | 13 | −24, C |
| | 14 | Test |
| | 15 | 25, Cl |
| | 16 | 23, Cl |
| * | 17 | Stop |
| | 18 | 0 |
| * | 19 | −a |
| * | 20 | b |
| | 21 | −3 |
| * | 22 | −b |
| | 23 | 1 |
| | 24 | remainder * finally zero |
| | 25 | 16 |

The items to the right of the asterisks must be correct — see Page 15 of Geoff's notebook actually recording comments by Geoff + me on 21 June 1948.

W. K.

# The First Program

## Recorded by Tom Kilburn, 29th March 1996

Chris and Geoff, I am making this tape because I really want to chat to you and I can chat better on it than by writing to you.

Following the launch at the Town Hall I decided to try to reconstruct the first program because I understand, Chris, that you want to run the first program in 1998. It's rather early yet and I certainly don't want to distract you from the main thing which is to build the Baby machine so the release of anything is entirely at your discretion so don't feel pressured in any way.

Following the launch I made an attempt at the first program and phoned this to Geoff because Geoff was the only person actually present when the first program ran apart from myself. Geoff remembered –which I didn't– that there was a page 15 of his notebook on which both he and I had written comments. This page 15 completely transforms the possibility of reconstructing the first program because it is the purpose of this tape to put up the proposition that there is no doubt about what the first program was. Of course, you will release this information eventually to your colleagues in the Computer Conservation Society, Chris, with the hope that they can break down that last statement. If they can't then we can conclude with a good degree of certainty that this is indeed the first program.

Having received back from Geoff his attempt at the first program based on page 15 –which you have a copy of, Chris, I believe– I tried to reconstruct the program having forgotten about it for a couple of days and came to the enclosed program which comes along with this tape.

I want to now talk about what the thoughts which I believe were in my mind – believe with some certainty were in my mind– when I first wrote the program; and some of these thoughts explain why page 15 is as it is. The program should be considered as if it were merely the section of a program because one of the things mainly exercising my mind when I devised the instruction set was the problem of getting in and out of sections of program; we would now call these sub-routines – are they still called that?

If we look at the first instruction to ensure that entry to the sub-routine is clean it is reasonable to clear the accumulator because otherwise lying around in the accumulator (called computer here, the letter C being used), as I say, lying around in C might be residue; so a sensible precaution might be to clear the accumulator. This accounts for the missing instruction from Geoff's reconstruction. It also accounts for the first line of the section below the list of instructions, namely 18. This contains nought which is written to the accumulator by the first instruction. At this point I wish to assert that there is good probability –indeed a very good probability– that the lines 18, 19, 20, 21, 22, 23,24, 25 were indeed just written in the order in which the items there occurred in the program. This would be a natural thing to do and there would be no point in not writing them in the order in which they occurred.

A more interesting point is that on exit from the program I wished to take the general case which is what I used to call a fork because the general way out of a program is to go to one of two places, sometimes the place is backwards in the list of instructions but in general it could be anywhere in either case. The fork became a passion and therefore one thing which I wanted to try in the program was not just an instruction in the program but a trio of instructions namely the trio 14, 15, 16. The fact that the stop instruction in placed at number 17 bears out this view because it is purely artificial – if it were not for wanting to keep the three instructions together as a group then stop would be placed in position 15. We have already, therefore, made what I think is an excellent case for instructions 1, 14, 15, 16, 17 being as they are.

We now come to the instruction which adds a number to control or the "relative transfer". The idea behind including this relative transfer is not because it is necessary; because it isn't. The idea is to allow a number stored to be added to control so that modification of this number is not affected by the position of the program in the store. There is an interesting aside here which is that at the time of the first program we were still referring to the control register but quite quickly afterwards we called it the control instruction and indeed in the Baby machine the function zero is used to identify the control instruction so that the control number extracts the next instruction, PI so we started referring to CNMPI.

If we transfer the additive from CI to PI we rapidly approach the index register concept or the B-tube concept which came very shortly after the first program and if we extend it even further and allow a decade to elapse then we have the idea that the instruction written by the programmer –at least the address part of it– is modified before being obeyed so that the machine actually obeys something different from what the programmer expects and we have paging and consequently because of the way in which paging was implemented, virtual memory or virtual store. However, that's a digression. But it shows that being a bit adventurous might pay off and it also shows that I wanted to include this instruction along with the other seven. You might ask why did we have a stop instruction rather than a loop stop. The answer was that one code was empty and why not use it for a stop.

Back now then to the program which was written to include all the instructions in the small set and we arrive naturally at instructions 2, 3, 4, 5 and 6. This group of instructions appears in exactly the same form in the amended version and accounts for lines 19, 20, 21 and 22 in that order. Line 8, 9 10, 11 and 12 are also natural and appear in the amended version and account for line 23. There remain lines 7 and 13 which tend to go together and are a section of their own. It is clear to me at this point that in 1948 I had a choice: I could either place the group 8–12 after the test at 14 or I could leave it where it is shown. If I did put it after the test then my trio would be destroyed; if I left it where it is, then in order to get the highest factor I would have to add one to line 20 because of the overshoot at the end of the program. There is no doubt in my mind that the preservation of the trio would come out on top because there is really no significance to the program beyond the fact that it is going to tell us whether the machine works or not.

Having decided that the group 8–12 inclusive should be placed before the test at 14 then the pair of instructions 7 and 13 which would normally be side by side have to be split and the remainder is stored in 24. Finally, in order to reach the stop, 16 is stored in 25. This program does what it set out to do. I look back on it with some pleasure

because sometimes one regrets taking a particular course but in the case of this program that is not the case.

The other way of looking at this program –especially having run it and demonstrated that the machines works and so on and so forth– the other way is to regard it as a test program. In this context there are obviously two redundant instructions: number 1 and number 15. They have no value in the use of the program for maintenance purposes. As Geoff pointed out, they can be omitted. Further, in order to stop the problem of having to load too many things, if B is copied plus and minus using four orders then we arrive at the amended version. It is interesting to note that before the amended version was copied into Geoff's notebook four weeks had elapsed and indeed, before the letter to *Nature*, the only other contemporary evidence available to us, six weeks had elapsed. I find it hard to believe, Geoff, that we hadn't felt the need for the amended version as a test program and maintenance program long before the 18th July 1948. Can it be that we had been using this program for a long time before that date and that this was merely the date in which the program was copied by you into your notebook? I would like your comments on this when we meet again, if ever, before 1998. My own recollections are that the sequence between the running of the first program and the *Nature* letter went for me something like this: with the running of the first program the cathode ray tube store project was not complete until a much longer run had occurred so that I think that quite quickly after the first run the 52 minute run was done. With that run I felt that the project of the cathode ray tube store was complete and I went off to write my thesis, coming into Manchester at less frequent intervals. The writing of the thesis took a long time because the diagrams, a major obstacle, were done by Joe McCormick in his spare time as a member of the departmental workshop team. It also took a long time because in spite of the fact that in the previous December most of the CRT stuff had appeared in my report to TRE, I actually wrote a significant amount about the Baby machine. On one of my days in, Freddie Williams advised me to cut this out and confine myself to the cathode ray tube store because this was more than enough to get a PhD. The reason for cutting it out was that work submitted for a PhD could not be used in a DSc and so, unfortunately for the present project, a contemporary account of the Baby machine does not, so far as I know, exist.

I had completed writing my PhD by the end of July and leaving my sister to type it –she kindly volunteered– I went off on a fortnight's holiday. My last act before going on holiday was to write the letter to *Nature*. This was not high on my list but Freddie Williams thought we should write this letter and I did so. I made a point of my authorship of this letter because I believe there is an error in this letter and this might have a bearing on the first program. It is fairly complex to explain but I hope I can do it properly. First the easy part: the letter refers to 17 entries in the program and therefore almost certainly was run as a result of the first program rather than the amended program. The 52 minute run is referred to and is simply a matter of record. The highest proper factor $2^{18}$ and the trial factor $2^{18} - 1$ are recorded and the obviously correct statement that 130,000 numbers were tested is also mentioned but then we come to the interesting part which says that "some 3.5 million operations were performed" for operations, read store accesses. We therefore are involved, or I was involved, in doing a little sum which said since each instruction requires two accesses, except for the test instruction, how did I arrive at 3.5 million? I think I did this as follows. I assumed that the number of instructions in the loop was 15. This gives 30 accesses. The top

test instruction was used twice before we got the number going negative. The bottom instruction was used once so that the number of accesses per trial number was 15 times 2, thirty, minus 3 equals 27. If we multiply 130,000 by 27 we get 3.5 million operations. However, the first program, which is enclosed with his tape, contains 16 instructions in the loop. It is therefore the only thing in the documents which were current at the time which conflicts with the first program as enclosed and it is open to anyone to try to write a program which has 15 instructions in the loop and prove that a different program to the one I am suggesting –and Geoff is suggesting– is the original. What I suspect happened is that either I miscounted the number of instructions in the loop on the day I wrote the letter or I didn't count but 'remembered' from the run more or less six weeks before writing the letter. This seems to me to be the sort of thing that could easily happen and I cannot myself write a program with 15 instructions in the loop. For the time being I will end my comments on the list of instructions there, but I would like to make a comment about the actual number which we used, that is a the number in line 19. I am pretty certain that this number was prime. The reason is I feel that I can remember explaining to Freddie Williams that when Geoff and I had run the program for the first time –I asked Geoff to fetch Freddie– I think I can remember explaining to him that what to look for was a zero in line 20 because of the way the program was written one had t0 be added to the zero to show that the number used was prime. Further, the number would be a small prime because this program must have been about for a considerable time because we must have tried it in the previous days as we were trying to make the machine work many many times before. We wouldn't therefore want the trial runs with a potential success to exceed lets say a few seconds; certainly we wouldn't want it to be minutes. My memory is that the run was extremely short, possibly no more than one or two seconds but I'd definitely like you to think about this, Geoff, if you would, and give me what your impression of this is. For your guidance I estimate that the prime number 19 would take half a second, 0.6 I think, and the prime number 31 would take 1 second. As you may remember, at the Town Hall, there was a simulator. This had been done by Andy Molyneux and he has promised to run anything we like on this simulator so if you care to suggest a prime number Geoff, I would be very grateful. I believe the numbers on page 15 were put there in the afternoon and the runs are far too long for them to be the numbers involved.

I have enjoyed this chat but it's been a little one sided and I am hoping to hear your sides when I see you again. All the best. I think that in three weeks since the Town Hall we have come a long way.

Transcribed by Joanne Allison
28 May 1996