**The Four Generations of Computers**
*Colossus: The World's First Electronic Computer*

**Dianne Larrington (commentary):**
Secrecy has always surrounded the invention and development of new technologies, especially when the driving force behind them has been the military.

During the Second World War, the top secret code-breaking base at Bletchley Park became the home for a closely guarded piece of new technology. Here, teams of code-breakers deciphered encrypted messages from German High Command and forged what became a devastatingly effective relationship with the world's first programmable electronic computer

– Colossus.

Designed by English engineer Tommy Flowers, ten of these computers were in operation at the base, and the advantage they and the code breakers gave to the allied forces probably shortened the war by around two years! After the war, all the machines along with their drawings were destroyed. Maintaining secrecy was crucial to the very end.

Decades on, Bletchley Park now plays host to The National Museum of Computing.

The centrepiece of the museum is a replica of Colossus, built by a team led by Tony Sale.

**Tony Nixon:**
Tony, given that all these machines were destroyed after the War and the whole thing was shrouded in secrecy, how on earth did you manage to build this one?

**Tony Sale:**
Well, I managed to come across 8 black and white photographs which had been kept at the end of the war and 10 fragments of circuit diagrams kept illegally by engineers as engineers always do. And that enabled me to actually make a start on the rebuild – 15 years, and here it is beginning to work now.

**Tony Nixon:**
This looks like the data input end to me.

**Tony Sale:**
Yes, this is the data input end here. What we have here is a radio intercept coming from Germany intercepted on radio receivers, punched onto paper tape and then loaded onto Colossus there as an endless loop. And that's being read optically there by Colossus at five thousand characters a second. That's the data going into Colossus. Colossus has got no memory. The data goes in there over and over again and then Colossus is using its two and a half thousand valves and logic circuits in order to analyse the cipher text in order to work out the wheel positions used on the Lorenz machine by the German operator to encipher that message, because that's what you've got to find to be able to decipher it.

**Tony Nixon:**
Could we look at the programming?

**Tony Sale:**
Yes, well that's done on these switch panels over here and the data flows from the paper tape reader into Colossus, into all its logic circuits. And it's comparing these patterns against the cipher text and looking for the maximum score which tells you you've found the correct position of the patterns. And that is done on the switch panels here. First of all this is the lamp

panel which is showing the output of the calculations all the way down the tape. So the rhythm of Colossus is join, join, join and in that interval Colossus has done brilliant calculations on six thousand characters all the way down that tape and put the results onto the lamp panels here. And when you're doing it for real, then what you're doing is, you're stepping the possible wheel start position round every time the tape goes round, and you're looking for the maximum score. It's found the maximum and it's printing it on the typewriter. And you've got to find twelve wheel positions, so that could take anything up to six hours, going over and over the cipher text analysing it. And when you've got all the wheel positions out, then you take those positions through to the Tunny machine, read in the cipher text and if you've got it right, out comes the German decrypt.

**Tony Nixon:**
Wonderful. And this machine, it's valve technology, yes? It's a first generation machine.

**Tony Sale:**
Valves. Two and a half thousand valves on this machine, eight kilowatts of power.

**Tony Nixon:**
That's four electric fires.

**Tony Sale:**
Yes, that's right. So it gets very, very hot in this room indeed, and the Wrens who operated Colossus and not being wasteful of anything, they used to put a clothes line across the top of Colossus and dry their smalls above it.


Tommy Flowers knew that valves were very reliable providing you didn't switch them on and off. That's what broke the valve in your radio or television set. So in wartime the Colossi were assembled and then never switched off. Now we can't do that because of the eight kilowatts, and so we've got a variable transformer, Variac, which brings the heaters up very, very slowly and takes them down again. And that protects the valve filaments. So, on a two and a half thousand valve machine valve failures are only about four or five a year which is quite remarkable. It's a remarkably reliable machine.

**Tony Nixon (commentary):**
Colossus is one of many computers housed here. Looking at these early machines you can see an absence of the things we take for granted nowadays like interactivity, monitor screens and portability. All these came about gradually as the technology evolved.