How we made the compact disc

An international collaboration between Philips and the Sony Corporation led to the creation of the compact disc. Kees A. Schouhamer Immink explains how it came about.

Kees A. Schouhamer Immink

In 1973, I joined the optics group of Philips Research in Eindhoven to work on the videodisc, a 30-cm-diameter optical disk that can store up to 60 minutes of analogue video and sound. The launch of the videodisc in 1978 was a technical success, but since consumers showed little to no interest it was deemed a failure for Philips.

In the early 1970's, Lou Ottens, technical director of Philips's audio division, requested a prototype of an audio-only disk based on the videodisc technology. Believing that such a sound-only disk was a trivial matter since the videodisc that had been previously demonstrated, my research director at the time, Piet Kramer, asked two engineers from Philips's audio division, Loek Boonstra and Toon van Alem, to develop the audio-only disk. They fared well and, in 1976, they demonstrated the first prototype of a digital audio-only disk using videodisc technology.

In October 1979, Philips and Sony decided to join forces in the development of a digital audio disk standard. I had nothing to do with the hard work on prototyping the audio-only disk. I was first involved when the small joint Sony/Philips task force of experts was formed. Since there was no one else available within the optics research group, I was named the 'expert' who dealt with servos, electronics, and coding (apart from reading a textbook, I had no expertise in this particular field).

Between 1979 and 1980, five expert meetings, alternating between Tokyo and Eindhoven, were held. There were many important parameters to be discussed and decided: playing time, disk diameter, error-correcting code, and sound quality. Playing time and disk diameter are probably the most visible parameters for the general public, and these two are, of course, related: a 5% increase in disk diameter yields 10% more disk area, and thus a 10% increase in playing time. Philips director Lou Ottens, who developed the compact audio cassette in the 1960s, proposed a 115-mm disk diameter. The cross diameter of the compact audio cassette, which was very popular at that time, is 115 mm. He reasoned that since it was a major success, the compact disc should be the same size. Sony, no doubt with portable players in mind, initially advocated a 100-mm disk.

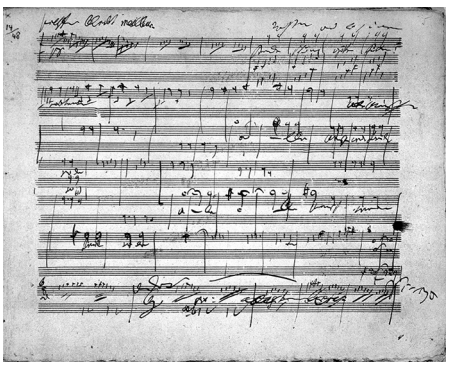

Fig. 1 | Sketches for Ludwig van Beethoven's Symphony No. 9 in D minor, Op. 125. Credit: Granger Historical Picture Archive / Alamy Stock Photo.

In December 1979, during the meeting in Tokyo, the partners agreed that the sound quality would be 16-bit (44.1 kHz sampling frequency), the error-correcting code would be Sony's CIRC (cross-interleaved Reed–Solomon code), the playing time would be 74 minutes, and the disk diameter would be 120 mm. The disk diameter is a remarkable choice as both partners initially preferred a smaller disk. Philips's website with the 'official' history states that "the playing time of the CD was determined posthumously by Ludwig van Beethoven". Sony's vice-president at the time, Norio Ohga, insisted that he wanted the composer's ninth symphony (Fig. 1) to fit on a single disk. He had identified that the longest known performance lasted 74 minutes and 33 seconds. This was a noisy mono recording made during the Bayreuther Festspiele in 1951 conducted by Wilhelm Furtwängler. For the state-of-the-art at the time we calculated that a diameter of 120 mm was required for Beethoven's ninth. The change of diameter from 115 to 120 mm had a dramatic effect on Philips's planning as their player design and disk manufacturing were all based on 115 mm.

It is plausible that Norio Ohga was a great fan of Beethoven's ninth, but he must also have been well aware of the significant consequences for Philips's planning. There are also other reasons to suggest that the Beethoven story for determining the playing time might be a myth. In the first place, the channel code was not yet decided in December 1979. Within two months, I was able to increase the playing time by 30% by designing a new code, 'EFM' (eight-to-fourteen modulation). A little arithmetic shows that with the new channel code a disk diameter of 100 mm would accommodate the requested 74 minutes playing time. The second reason is that in October 2017 I had a lunch conversation in the Takanawa Prince Hotel in Tokyo with my brother in arms, Sony's top-engineer, Toshitada Doi, who, when I told him about my doubts about Beethoven, said, "Of course you are right, but it was a good story, wasn't it?" ❐

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Published online: 17 April 2018
https://doi.org/10.1038/s41928-018-0063-7