

Printed Circuit Board

Ask yourself, what is the most fundamental building block of electronics? I propose that interconnects is the answer. Interconnects dominates the subject matter of IEEE Electronics Packaging Society (EPS) publications. So the next question is what the first revolutionary step in evolution of interconnects? It is the printed circuit board.

On my bookshelf, I have a copy of the book by Clyde Coombs titled *Printed Circuits Handbook*. I have relied on this book as my primary reference since the 1980s. The first line of the second chapter (written by Dr. Hayao Nakaharar), credits Paul Eisler with the invention of printed wiring technology. Fortunately, the inventor of the printed circuit board (PCB) published an autobiography. The inventor of the PCB was Paul Eisler. He was born in Vienna, Austria in 1907 and died in London, England in 1992. His book is titled *My Life with the Printed Circuit* which was published in 1989, and reading this book explains much about working in electronics and electronics packaging.

Before delving into Eisler's story of invention, we need historical context about the long turmoil in the Central Europe of his youth. In the 19th century, there was a broad cultural movement brewing within Europe appropriately known as "romantic nationalism", and this movement fomented tumultuous political strife. Relevant to Eisler's story is that after WW I, the German Nationalist movement in Austria made professional life (such as finding employment) difficult for young Paul Eisler who had Jewish heritage. In Eisler's book, he outlines how this employment situation contributed to his long creative career.

The common English expression "necessity is the mother of invention" describes how Eisler's invention diffused, the work economists would use, from concept to widespread practice. As with other freelance inventors, perfecting and commercializing his inventions faced a tortuous path. In his autobiography, Eisler refers to the struggles of Chester Carlson to promote his invention of the photocopier.

Invention requires capital to fund prototypes and related legal activities such as contracts; a common expression for those with capability to fund business activities is "deep pockets". Both Eisler's and Carlson's experiences struggle for funding should be enlightening to anyone interested in taking the path of inventing. Today, many inventors seek funding through an established industry of venture capitalists. In the early 20th century, finding capital was difficult. Eisler eventually was brought on by a long established publishing company, Henderson & Spalding.

While working for Henderson & Spalding, Eisler produced his first printed circuit board prototype in 1942, and he filed his first patent application in 1943. Although the printed circuit board was a British invention, the Americans implemented the printed circuit board first. Eisler's first granted US patent was US 2,441,960 in 1948.

After demonstrations in England but independent of Eisler, the United States used the printed circuit board in their new antiaircraft proximity fuze. The embodiment was silver traces painted on ceramic boards. These new fuzes were produced in quantity and placed into service. Eisler writes that approximately 4000 German V-1 rockets were shot down in England, alone, by using these proximity

fuzes. Noteworthy, the IEEE-USA Harry Diamond Memorial Award was established in recognition of Diamond's work on the proximity fuze.

As industry adopted the printed circuit board in the 1950s, this technology story became more focused on competitive challenges and regulatory conflicts. I explained how the adoption of the printed circuit board drove the creation of what is now EPS in a previous newsletter. The IPC was formed in 1957, and the IPC has produced widely accepted standards for printed wiring boards. Over the ensuing decades, the printed circuit board business grew from these roots to somewhere on the order of 70B\$ today.

On January 1st 2019, the New Horizons spacecraft, launched in January 2006, flew by the most remote object, Ultima Thule, ever intercepted by a spacecraft. The scientific payload included the Radio Science Experiment (REX) developed by Johns Hopkins University Applied Physics Laboratory and Stanford University and is described on the JHUAPL website as a 100 gram PCB.

The printed circuit board is one of the remarkable enabling technological successes of electronics, an accomplishment initiating from Paul Eisler.

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