



TRANSFORMERS, THE UNSUNG TECHNOLOGY



➤ I HAVE ALWAYS DISLIKED EXAGGERATED CLAIMS of imminent scientific and technical breakthroughs, like inexpensive fusion, cheap supersonic travel, and the terraforming of other planets. But I am fond of the simple devices that do so much of the fundamental work of modern civilization, particularly those that do so modestly, even invisibly. • No device fits this description better than a transformer. Nonengineers may be vaguely aware that such devices exist, but they have no idea how they work and how utterly indispensable they are for everyday life. • The theoretical foundation was laid in the early 1830s, with the discovery of electromagnetic induction by Michael Faraday and Joseph Henry. They showed that a changing magnetic field can induce a current of a higher voltage (known as “stepping up”) or a lower one (stepping down). But it took another half century before Lucien Gaulard, John Dixon Gibbs, Charles Brush, and Sebastian Ziani de Ferranti could design the first useful transformer prototypes. Next, a trio of Hungarian engineers—Ottó Bláthy, Miksa Déry, and Károly Zipernowsky—improved the design by building a toroidal (doughnut-shaped) transformer, which they exhibited in 1885. Though it worked well, its winding was difficult to make. • The very next year that drawback was fixed by a trio of American engineers—William Stanley, Albert Schmid, and Oliver B. Shallenberger, who were working for George Westinghouse. The device soon assumed the form of the classic Stanley transformer that it has retained ever since: a central iron core made of thin silicon steel laminations, one part shaped like an *E* and the other shaped like an *I* to make it easy to slide prewound copper coils into place. • In his address to the American Institute of Electrical Engineers in 1912, Stanley rightly marveled at how the device provided “such a complete and simple solution for a difficult prob-

lem. It so puts to shame all mechanical attempts at regulation, it handles with such ease, certainty, and economy vast loads of energy that are instantly given to or taken from it. It is so reliable, strong, and certain. In this mingled steel and copper, extraordinary forces are so nicely balanced as to be almost unsuspected.”

The biggest modern incarnations of this enduring design have made it possible to deliver electricity across great distances. In 1890, de Ferranti stepped up from 2.5 kilovolts to 10 kV, enough to bridge 11 kilometers in London. Now ABB, based in Zurich, is working on stepping up to a record-breaking 1,100 kV, to span more than 3,000 km in China.

The sheer number of transformers has risen above anything Stanley could have imagined, thanks to the explosion of portable electronic devices that have to be charged. In 2016, the global output of smartphones alone was in excess of 1.8 billion units, each one supported by a charger housing a tiny transformer. You don’t have to take your mobile phone charger apart to see the heart of that small device: A complete iPhone charger teardown is posted on the Net, with the transformer as its single largest component.

But many chargers contain even tinier transformers. These are non-Stanley (not wire-wound) devices that take advantage of the piezoelectric effect—the ability of a strained crystal to produce a current, and of a current to strain or deform a crystal. Sound waves impinging on such a crystal can produce a current, and a current flowing through such a crystal can produce sound. One current can in this way be used to create another current of very different voltage.

And the latest innovation is solid-state transformers. They are much reduced in volume and mass compared with traditional units, and they will become particularly important for integrating intermittent sources of electricity—wind and solar—into the grid and for enabling DC microgrids. ■

➤ **POST YOUR COMMENTS** at <http://spectrum.ieee.org/transformers0817>