



Memorials to N. Holonyak, P. Sauer, and W. Wulf, and commemoration of the 75th anniversary of the transistor.

Steps toward modern electric transport and the growing electronics revolution.

National Academy of Engineering Regional Meeting

April 4, 2023





In Memoriam

Three giants in their respective fields, linked to the University of Illinois Urbana-Champaign and members of the National Academy of Engineering, have passed away recently.



Nick Holonyak, Jr. (1928-2022)

- Credited with the development of the first practical visible-spectrum LED, now commonly used worldwide in lighting, device displays, and lasers.
- Part of the team that invented semiconductor thyristors, starting with SCRs and TRIACs.
- John Bardeen's first graduate student, earning his doctorate at Illinois in 1954.
- Awards include the Queen Elizabeth Prize for Engineering (2021), the NAE Draper Prize (2015), the Lemelson-MIT Prize (2004), the Global Energy Prize (2003), the IEEE Medal of Honor (2003), the Japan Prize (1995), the NAS Award for the Industrial Application of Science (1993) and the Charles Hard Townes Award (1992). NAE election: 1973.



Pete Sauer (1946-2022)

- Credited with fundamental developments in electric power system dynamics and stability and in dynamic analysis of synchronous generators.
- Co-founder, national Power Systems Engineering Research Center (PSERC). Co-founder, PowerWorld Corp.
- Facilitator team for the "NextGrid Illinois: Utility of the Future Study" released in 2019.
- Awards include the IEEE Power & Energy Society Lifetime Achievement Award (2020), the IEEE Tesla Award (2022), and a long list of teaching awards. NAE election: 2003.



Source: Stephanie Kuykendal for The New York Times

William A. Wulf (1939-2023)

- Earned a BS in physics and an MS in electrical engineering at the University of Illinois Urbana-Champaign, and a PhD in computer science from the University of Virginia.
- Joined faculty at Carnegie Mellon - left in 1981 to found Tartan Laboratories with wife Dr. Anita Jones.
- At National Science Foundation, he expanded access to Arpanet.
- Served as president of the NAE from 1996-2007.
- Awards include the ACM Policy Award, the ASME Ralph Coats Roe Medal, and the ACM Karl Karlstrom Outstanding Educator Award. NAE election: 1993.

The SCR (1957) drove the reinvigoration of the electric car

General Motors and Ford projects date from about 1964 onward.

Prototypes into the 1980s used SCRs as primary power devices.

Motor and SCR inverter, Electrovaair II, 1966.
Macsmotorcitygarage.com



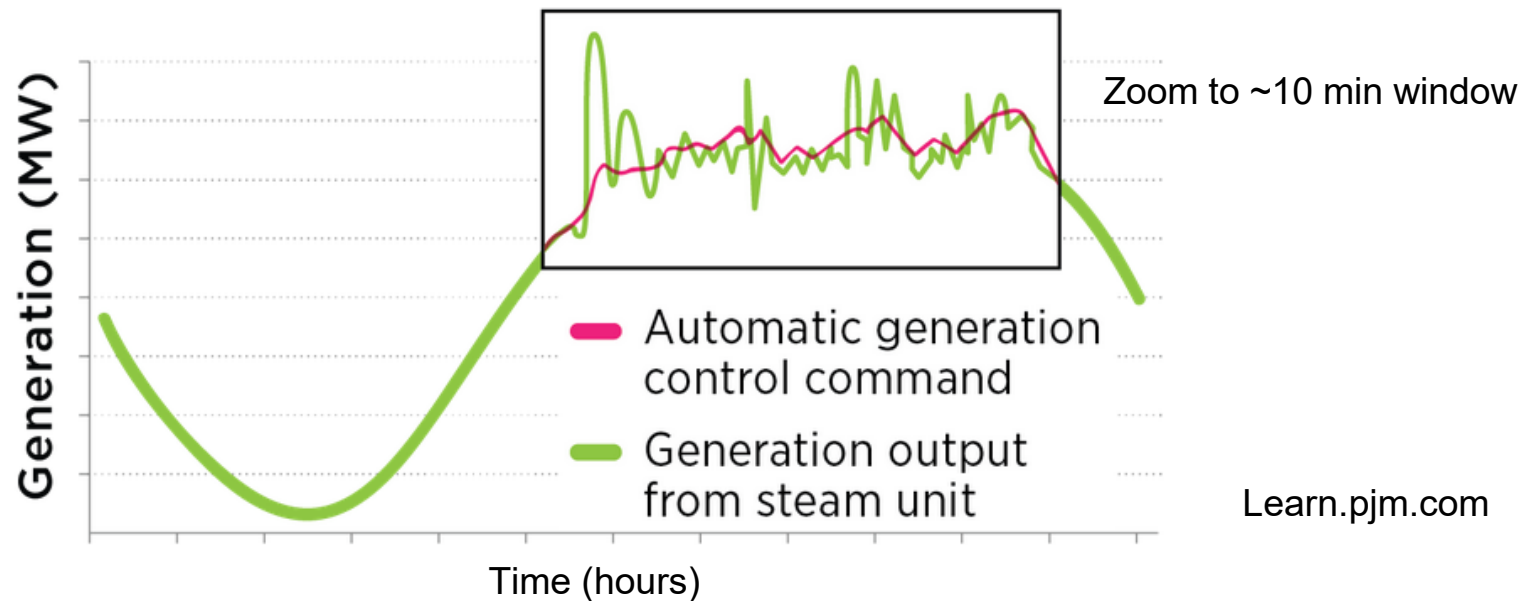
Electrovaair II, 1966. Autoevolution.com



Dynamic power grid regulation balances supply and demand with market mechanisms

Compensate imbalances by means of Sauer's analysis, control, and energy methods.

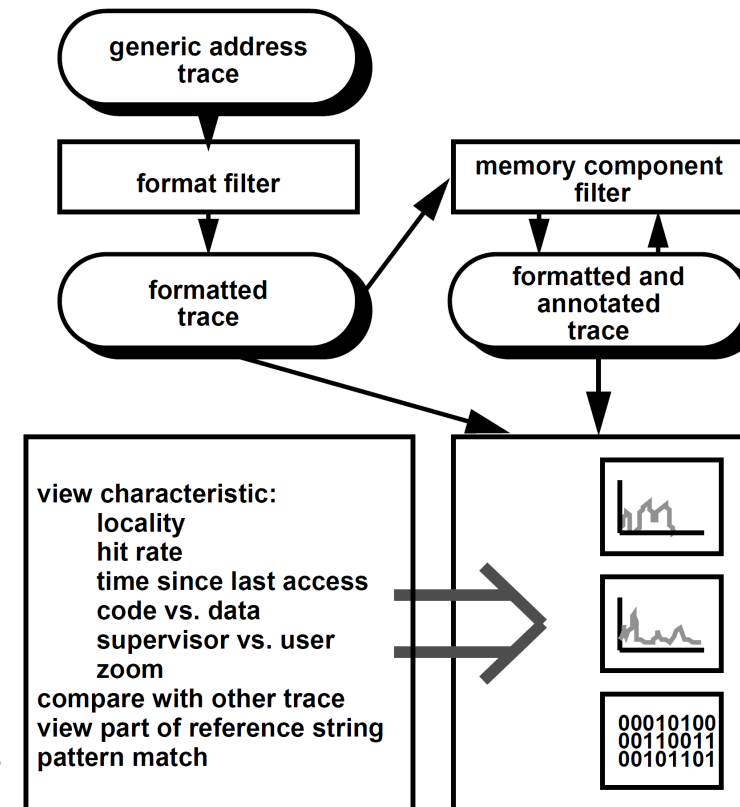
Connected electric vehicles are a near-ideal flexible load for fast demand adjustment.



Software reliability is critical for mobility electrification

Software reliability, and implementations such as the Hydra system, are pioneering contributions from Wulf.

Hardware-software codesign methods are vital.



Weikle, McKee, Wulf, "Caches as filters,"
Proc. Int'l. Symp. Modeling, Analysis,
Simulation Computer & Telecomm. Sys., 1998.

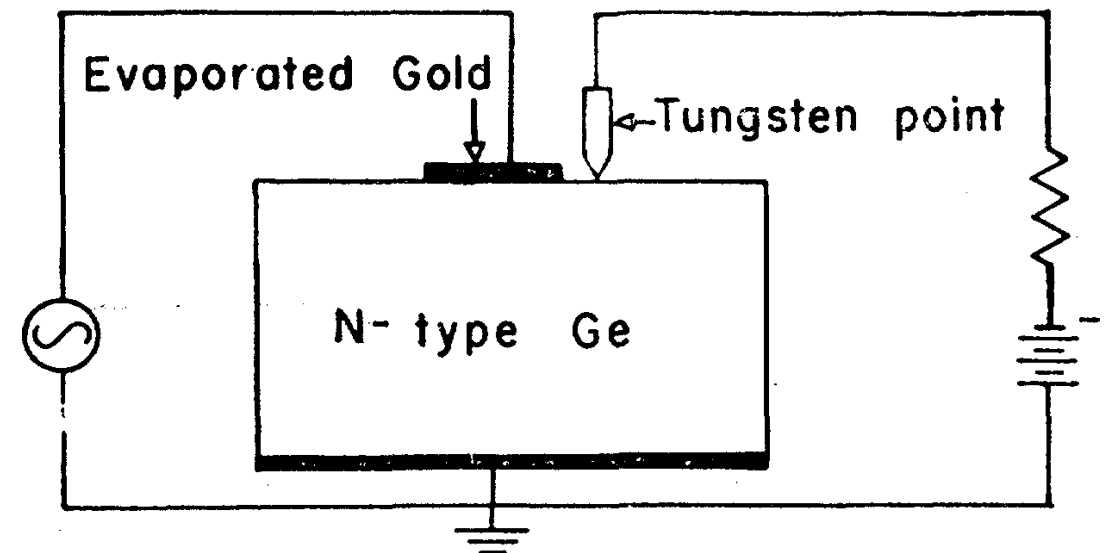
The point contact transistor, Bardeen, Brattain, Shockley, December 1947

Tungsten contact point on germanium bulk crystal.

With a few years, silicon bipolar junction transistors (BJTs) and metal-oxide-semiconductor field-effect transistors (MOSFETs) were in production.



Bellsystemmemorial.com



Bardeen, "Research leading to point-contact transistor," *Science*, vol. 126, July 19, 1957.

Two extremes today

We are approaching chip designs with 100 billion transistors based on 4 nm sizes.

At the other end, individual insulated-gate bipolar transistors (IGBTs) and large MOSFETs for electric transportation are rated at up to 6500 V and 1000 A.



Infineon.com

These are workhorse devices for nearly all transportation applications.

There is an emerging transition to other materials, notably SiC.



Wolfspeed.com

Transistors continue to change everything

Since AC Propulsion powered the Sunraycer, the GM Impact/EV1, and their own tzero, essentially all electric transportation uses switching power transistors.



Autoweek.com, 3/1/2021



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