■ Abstract

The National Museum of Nature and Science has previously conducted comprehensive surveys on power generators (2005, 2006), power transformers (2004), and power system technologies (2020) within the domain of electric power systems. The present study extends this series by focusing on circuit breakers and switching devices, which are indispensable for ensuring the stable transmission and distribution of electricity from generation sources to industrial facilities and households.

Circuit breakers are critical components in power systems, alternating the circuit between conductive and insulating states to interrupt or restore current flow. To fulfil these roles, various interrupting media, including water, oil, air, vacuum, and sulphur hexafluoride (SF_6), have been employed to accommodate the increasing demands for higher operating voltages and greater interrupting capacities. Continuous technological advancements have driven profound transformations in both the external configuration and internal architecture of circuit breakers, reflecting continuous innovation in response to evolving system requirements.

The evolution of circuit breaker technology has been marked by several significant milestones:

- 1900
  Water circuit breakers were first introduced in the United Kingdom, with products rated at 10-60 kV and 1500 MVA subsequently manufactured in Germany.
- 1900-1910
  Oil circuit breakers gained widespread adoption, playing a pivotal role in the expansion of alternating current (AC) power supply networks.
- 1930-1960
  Oil circuit breaker technology advanced considerably, achieving ratings up to 345 kV-63 kA. These advancements also influenced the performance improvements of later air and gas circuit breakers.
- 1950-1960
  Air circuit breakers were standardized in multi-break configurations for voltages ranging from 36 to 735 kV, surpassing oil circuit breakers in both performance and reliability.
- Late 1950s
  Gas circuit breakers were put into practical use in the United States, evolving from the double-pressure type to the single-pressure type, thereby achieving greater compactness and enhanced operational reliability.
- After 1960s
  Gas insulated switchgear (GIS) emerged as a transformative technology. Japan assumed a leading role in global development through close collaboration between utilities and manufacturers, significantly contributing to the compactness and reliability of high-voltage substations.

For the author, who experienced the era dominated by gas circuit breakers, the opportunity to explore the historical development of oil and air circuit breakers and the associated milestones of technological innovation was of great significance. A particularly noteworthy observation was the rediscovery that, during efforts to enhance the performance of classical oil circuit breakers, fundamental concepts such as the arc-extinguishing chamber and the double-flow method had already been conceived. These principles remain integral to the design of modern gas circuit breakers, underscoring the enduring relevance of early innovations and the importance of learning from the achievements of our predecessors.

This survey provides a comprehensive overview of the technological evolution of circuit breakers and examines how Japan, while initially adopting Europe and the United States in areas such as arc-extinguishing chamber design, gas-blast techniques, and multi-break configurations, progressively established its own technological foundations. Through these advancements, Japan ultimately achieved world-leading reliability with the development of gas circuit breakers and gas insulated switchgear.