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# Lessons Learned From the 1998-2004 US Pirelli-Detroit Edison Cable Demonstration

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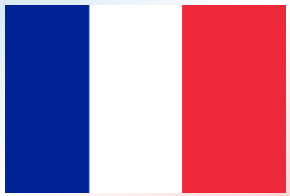
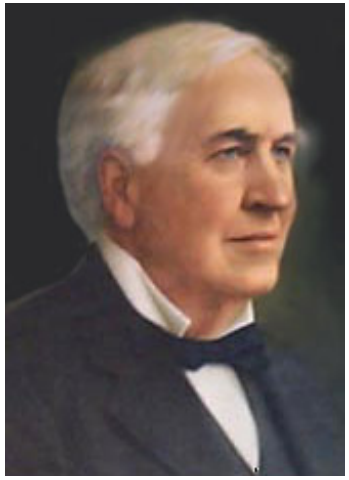


Aging IBM Pensioner

# Fathers of Electricity in America

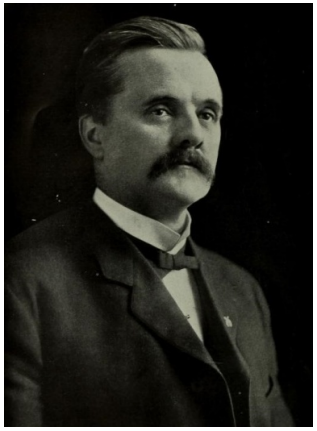
Steinmetz



Edison

Tesla

Samuel Insull



George Norris

Chauncey Starr

# "Ancient History"

*"Those who cannot remember the past are condemned to repeat it"*
*George Santayana*

- With the emergence of long distance telegraphic and electricity transmission throughout Europe and the US in the late 19th century, Pirelli in 1901 began exploitation of its rubber vulcanization IP to produce cables to service the emerging market.
- Pirelli quickly came to dominate production and installation of electric power transmission cables in North America.
- In the 1980s, Pirelli entered the market for fiber optic cables, again deploying similar production technology used for power lines.
- Now it's 1989. Pirelli spots a new opportunity (similar to that provided by fiber optics in communication) for commercialization of HTSC for electricity, especially in the US where it has dominated transmission cable deployment by American electric utilities for the previous seven decades.
- Pirelli thus undertakes a collaboration with American Superconductor to develop Bi-2223 "OPIT" HTSC tapes as the conductor basis for a new generation of high-delivery cables.
- It is important to note that this collaboration was initially funded by Pirelli, with later partial support from DOE and EPRI (i.e., NOT totally government sponsored!)

***...more...***

# ...Continued...

- Pirelli's vision: A market possibly exists for a "retrofit/replacement" HTSC transmission/distribution cable with the following idealized parameters:
  - 20-120 kV with the same form factor as conventional
  - 3 kA capacity (3x that of 1 kA conventional)
  - 2x cost of conventional
- By mid-1993, a 50-m "warm temperature dielectric" prototype "mock up" cable and terminations, satisfying the above I/V characteristics was built using AMSC "Gen I" wire, partially funded by EPRI, and successfully tested at Pirelli's South Carolina facility.
- Now, a few pictures...

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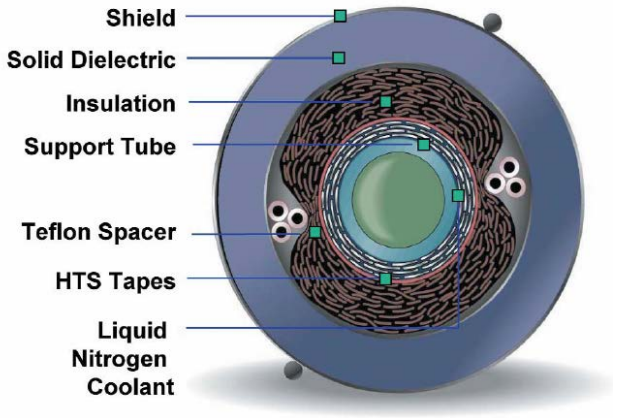
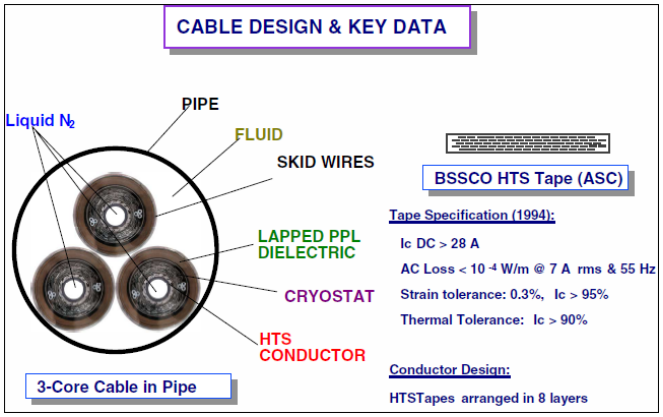
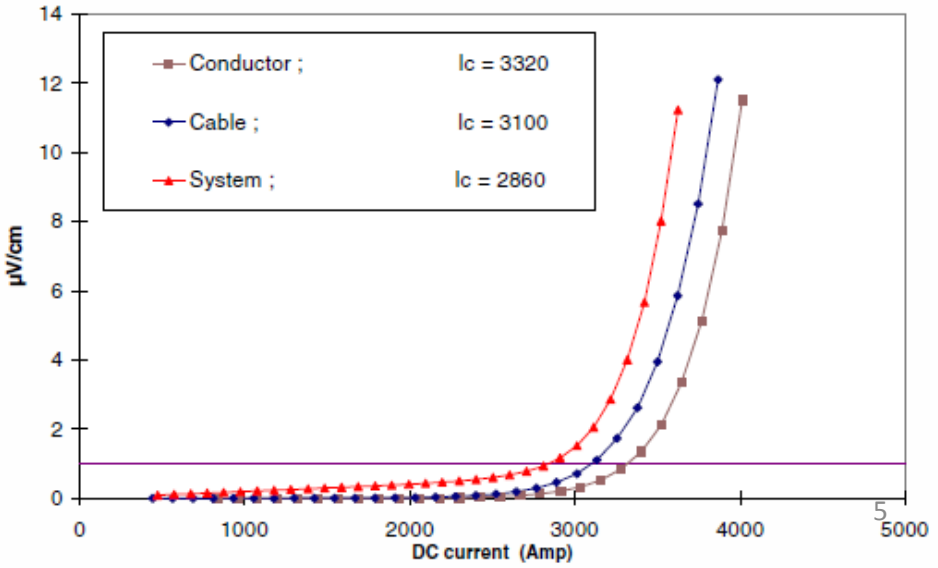
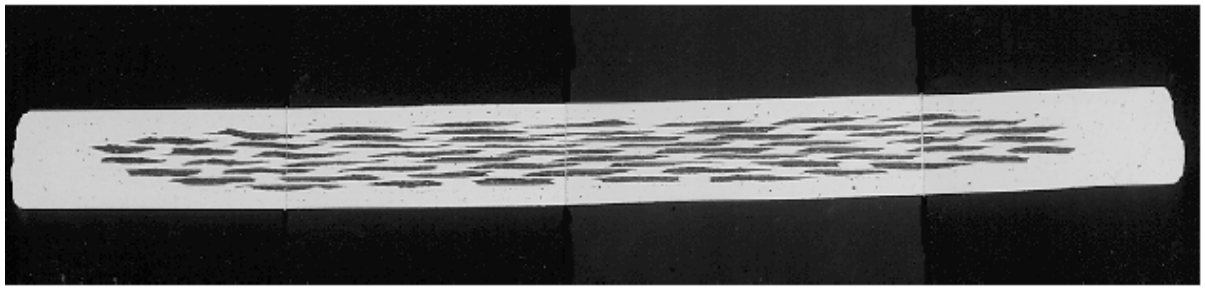
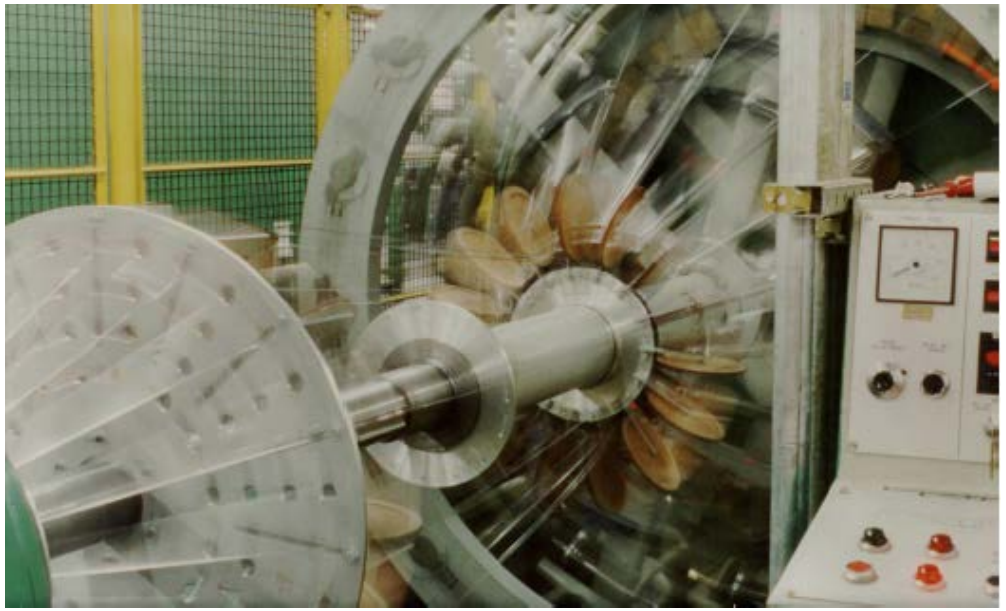
# "South Carolina" Photo Album







# "Middle Ages"

**Field Demonstration of a 24-kV Warm Dielectric Superconducting Cable at Detroit Edison**

*FY2003 Annual Progress Report*

**1002040**

- It's now 1998. EPRI joins with Pirelli, AMSC, DOE, and Lotepro to propose an in-field demonstration of the WTD cable concept with investor-owned utility, Detroit-Edison (DECO, now DTE).
- Why DTE?
  - During the decades following the 1960s, the economy and infrastructure in downtown Detroit declined rapidly.
  - However, with the advent of casino gambling in 1994 in neighboring Windsor, Ontario, it was anticipated that a new era of growth would occur in Detroit to service the tourist trade to follow that would pressure the aging urban electricity distribution network.
  - DTE viewed the Pirelli WTD concept as a solution that could double or triple power delivery to mid-town Detroit within the existing underground duct facilities.
  - DTE, established in 1908 and a founding member of EPRI, had a long established reputation as an early adopter of novel electric technologies.
- DTE's Frisbie substation, one of the earliest distribution substations in the US (1930), on the eastern metropolitan border of Detroit, was chosen as the demonstration site by reason of its ease of access and existing support facilities.
- Installation of three cables, each approximately 120 meters long, and attendant cryogenic, splice joint and termination ancillary requirement, was completed in late 2001.
- The intention was to operate each for 18 months, all the while monitoring performance, with subsequent removal and return to Pirelli to study any deterioration issues.

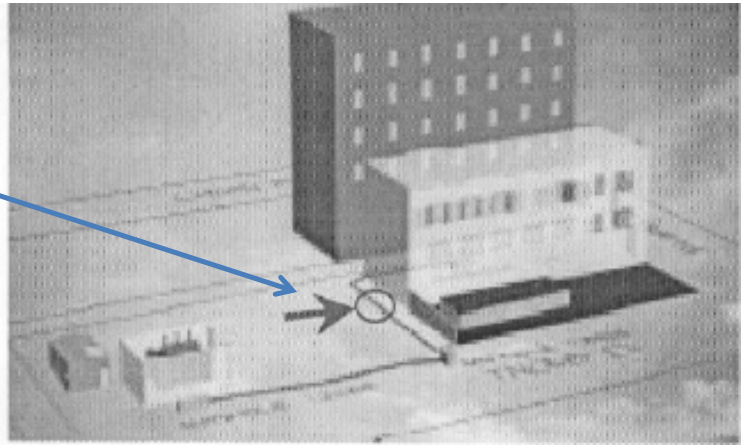
# "Milan-Frisbie" Photo Album

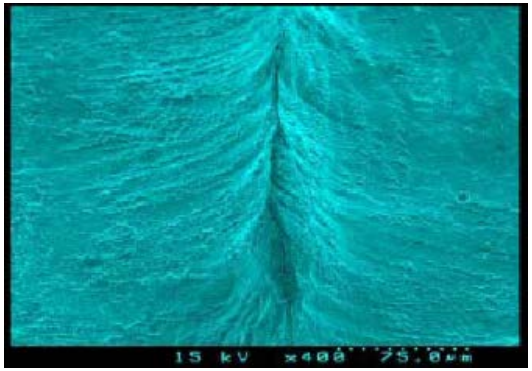

| | | |
|---|---|---|
| US DOE | $2,400,000 | 44 % |
| Pirelli | 1,120,000 | 21 |
| EPRI | 800,000 | 15 |
| ASC | 738,000 | 14 |
| Detroit Edison | 400,000 | 7 |
| Total | $5,458,000 | |

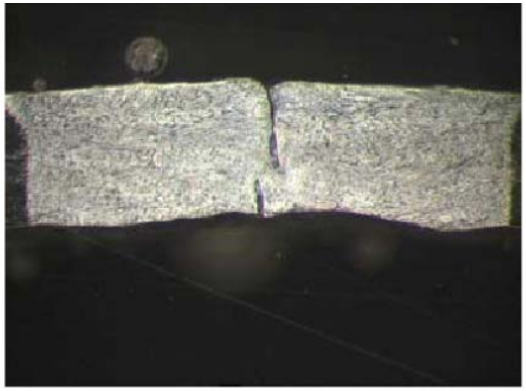
# "The Dark Age"

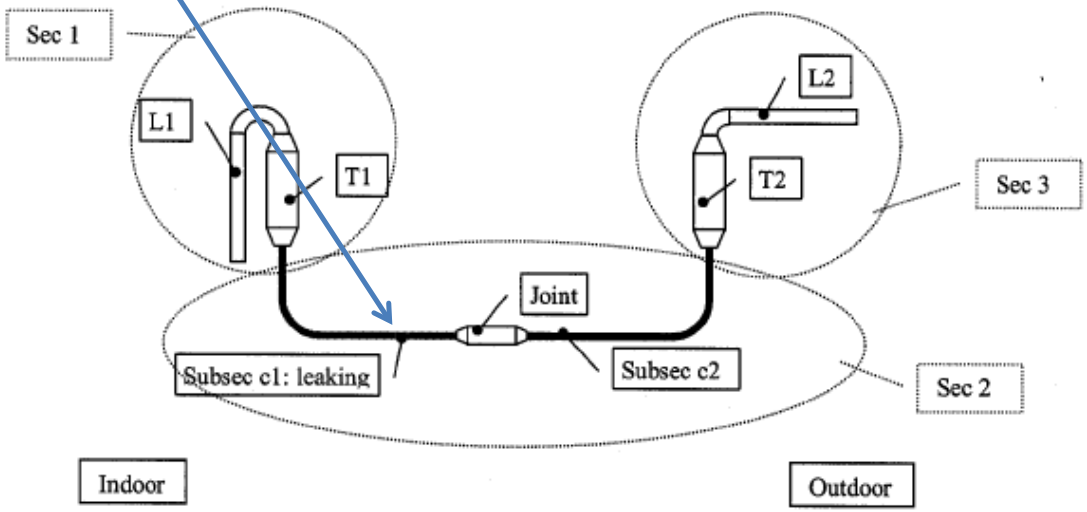
- In late 1998, AMSC detected "blister/balloon" issues in its "Gen I" due to LN2 diffusion though the silver binder. These were fixed prior to cable manufacture.
- However, after installation of the three WTD cables in Frisbie, it was found on initial "pump down," leaks of various severity were discovered in all three phases. Two of the cables were returned to Pirelli for further analyses.
- The remaining "third phase" cable exhibited "intermittent pressure instabilities" reaching roughly $5 \bullet 10^{-2}$ torr.
- Since the cable terminations shared their vacuum with the cable itself, this pressure represents roughly 10% of the Paschen discharge limit for gaseous $N_2$ at the substation distribution voltage of 24 kV, it was deemed unsafe to energize and connect to the DTE local grid.
- Subsequent metallurgical analysis of the stainless steel inner and outer corrugated vacuum barriers revealed microcracks, most likely caused by hydrogen embrittlement and amorhorphization induced by Pirelli's use of its standard production methods employed in its conventional hermetically sealed cable products.

Leaks emerged after pulling cable around the conduit bends

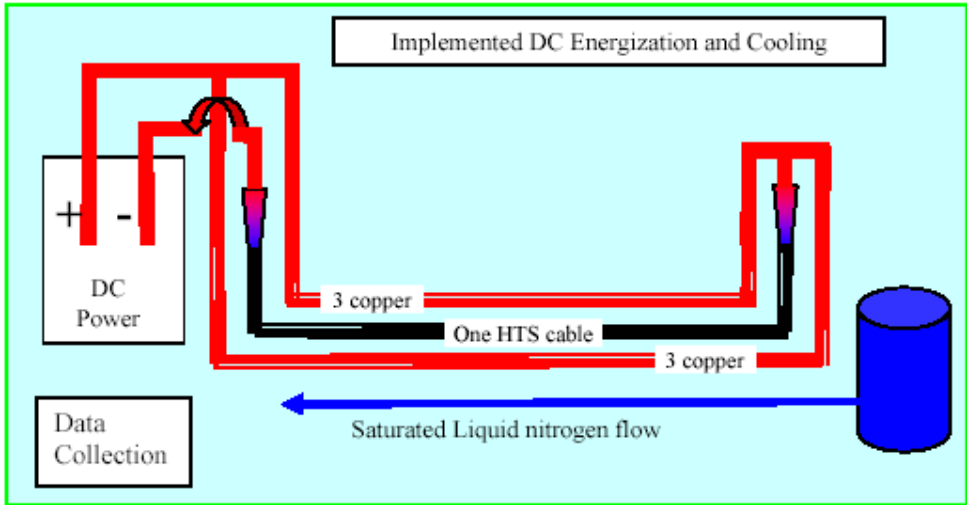


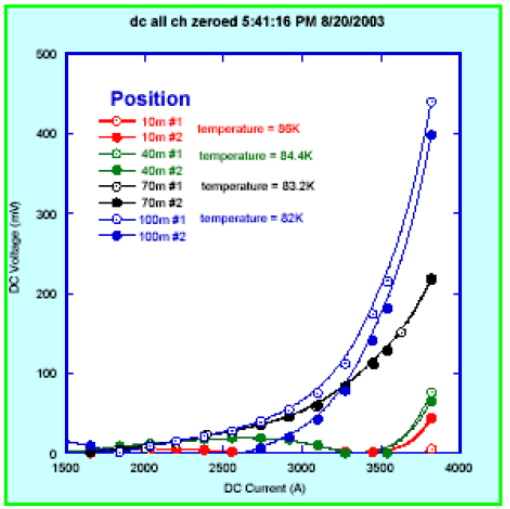


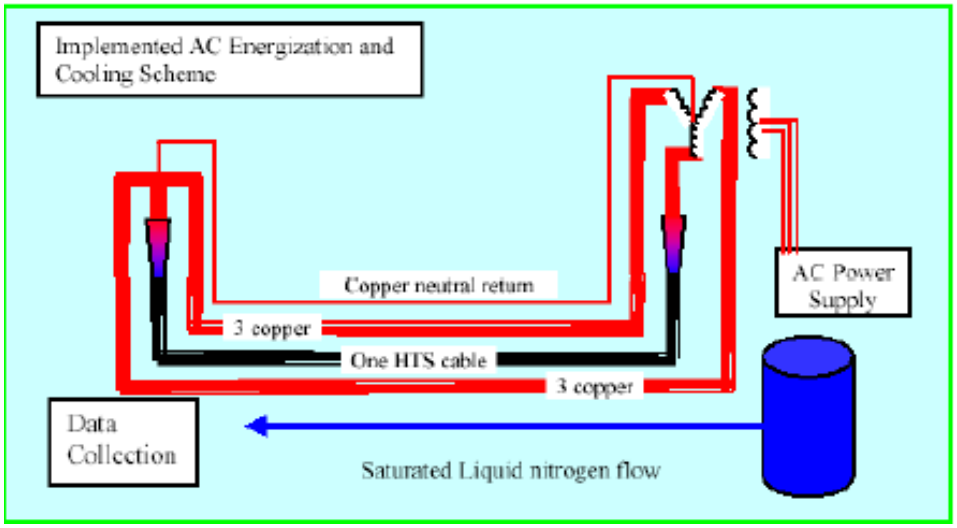



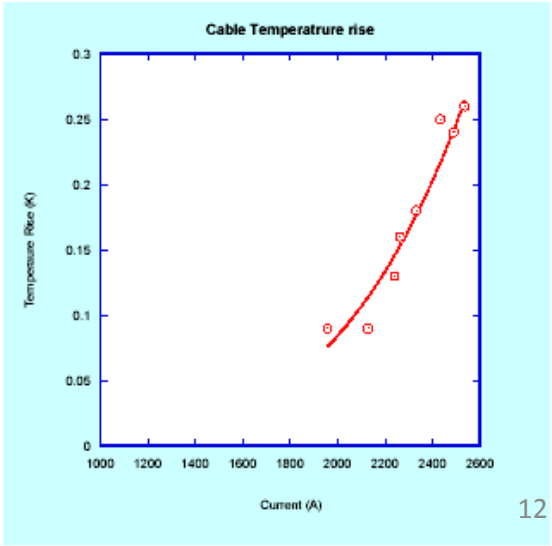


# "August, 2003 - A Brief Dawning"



# Why Did Pirelli "Park" HTSC Cable Development?

- It was NOT due to the problems encountered at Detroit Edison!
- Pirelli Timeline ($100 M, 1993 – 2002)
  - 1993 — SPI for EPRI/Pirelli Proto
  - 1998-1Q — SPI for Detroit Edison
  - 1998-4Q — "Blister/Balloons" found in Proto
  - 2001
    - May — Pirelli submits LIPA SPI proposal to DOE
    - July — Pirelli offers Energy Cables for sale
    - Sept — SPI to Pirelli for LIPA
    - Dec — Leaks found at Frisbie
  - 2002 — Pirelli withdraws from LIPA (business case needed, not more demos)
  - 2005 — Pirelli sells Energy Cables to G-S (Prysmian)

***Nota Bene! This slide was originally shown in my presentation, "Quo Vadis High-Tc," given at the DOE WDW, 31 January 2006!***

# Is There a Mass(ive) Market for HTSC Cables?

- Sale of Pirelli Cable Systems (now Prysmian) to Goldman-Sachs, July 2005
  - 12,000 Employees, 52 Plants (Energy + Telecom)
  - Sale Price $1.7 B
- 2004 Revenue & Profit
  - Revenue $4.2 B
  - EBIT $144 M
  - Profitability 3% !

***Nota Bene! The "bullets" shown are also taken "word for word," from my 2006 DOE WDW talk.***

# Lessons Learned (at least in the US)

- Deregulation (e.g., DTE) dis-encentified the IOUs from investing in new technologies without the opportunity to recover that investment from subsequent energy savings.
- Therefore, it is unlikely market opportunities will emerge for novel transmission technologies, such as HTSC, irrespective of cost reduction and energy savings.
- Capital markets in the US are targeting the “microgrid” instead.
- But maybe, just maybe, the Dual Use of fossil fuel transport ROWs will offer a resurrection...stay tuned!

# “You can’t always get what you want…”

# "…you get what you need!"