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- Exergy-Based figure of merit for regenerative and recuperative heat exchangers with application to multistage cryocoolers**
Arsalan Razani, Christopher Dodson, and Thomas Fraser 1830

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Ian Andrew Richardson and Jacob Leachman 1841
- Thermal conductivity of helium-3 between 3 mK and 300 K**
Yonghua Huang, Lei Fang, Xiaojian Wang, Ruzhu Wang, and Lie Xu 1849
- Apparatus for accurate density measurements of fluids based on a magnetic suspension balance**
Maoqiong Gong, Huiya Li, Hao Guo, Xueqiang Dong, and J. F. Wu 1857
- Performance of an ortho-para concentration measurement cryostat for hydrogen**
Juergen Essler and Christoph Haberstroh 1865

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Mihir G. Pathak, Thomas Mulcahey, and S. Mostafa Ghiaasiaan 1875
- Ideal thermodynamic processes of oscillatory-flow regenerative engines will go to ideal stirling cycle?**
Ercang Luo 1883
- Numerical simulations of oscillating flow and heat transfer in porous media by lattice boltzmann method**
Qunte Dai, Houlei Chen, and L.W. Yang 1891

A thermodynamic model for the effect of thermal boundary resistance on multistage thermoelectric cryogenic refrigerators
Arsalan Razani, Thomas Fraser, and Christopher Dodson 1899

Thermodynamic analysis and experimental verification on a novel looped pulse tube cryocooler
Xiaotao Wang, Ercang Luo, Wei Dai, Jianying Hu, and Yuan Zhou 1908

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Cryogenic distribution for the Facility for Rare Isotope Beams
S. Jones, Dana Arenius, Adam Fila, P. Geutschow, Helmut Laumer, Matt Johnson, Cory S. Waltz, and J. G. Weisend II 1919

Second law analysis and optimization of cryogenic transfer lines
Maciej Chorowski, Pawel Duda, Jaroslaw Fydrych, and Jaroslaw Polinski 1927

Preliminary system design and analysis of an optimized infrastructure for ITER prototype cryoline test
Nitin Dineshkumar Shah, Ritendra Nath Bhattacharya, Biswanath Sarkar, Satish Badgular, Hitensinh Vaghela, and Pratik Patel 1935

Forced flow supercritical helium in a closed heat transfer loop subjected to pulsed heat loads
Christine Hoa, Patrick Bonnay, Michel Bon-Mardion, Philippe Charvin, Jean-Noel Cheynel, Alain Girard, Benjamin Lagier, Frederic Michel, Lionel Monteiro, Jean-Marc Poncet, Pascal Roussel, Bernard Rousset, and Roser Vallcorba-Carbonell 1943

Adaptability of optimization concept in the context of cryogenic distribution for superconducting magnets of fusion machine
Biswanath Sarkar, Ritendra Nath Bhattacharya, Hitensinh Vaghela, Nitin Dineshkumar Shah, Ketan Choukekar, and Satish Badgular 1951

The experiments of 200-meter superconducting DC power cable in Chubu university and the estimation for longer cable cooling
Satarou Yamaguchi, Yury Ivanov, Jian Sun, Hirofumi Watanabe, Makoto Hamabe, Toshio Kawahara, and Atsuo Iiyoshi 1959

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Heat dissipation in accelerator superconducting cables with ceramic insulation in normal and supercritical helium Slawomir Pietrowicz, Aurelian Four, Bertrand Baudouy, Nobuhiro Kimura, and Akira Yamamoto	1969
Heat transfer through cyanate ester epoxy mix and epoxy TGPAP - DETDA electrical insulations at superfluid helium temperature Slawomir Pietrowicz, Aurelian Four, Simon Canfer, Stephanie Jones, and Bertrand Baudouy	1976
Effect of superfluid helium at the inner coil face on cooling and stability in superconducting accelerator magnets Erwin Bielert, Arjan Verweij, and Herman ten Kate	1983
A helium thermosiphon cooling loop for the APS superconducting undulator Daniel Potratz, John Pfothauer, Quentin Hasse, Yury Ivanyushenkov, Elizabeth Moog, and Robert Kustom	1991
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