History and Development of the Stirling Cycle Cryogenerator

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STIRLING

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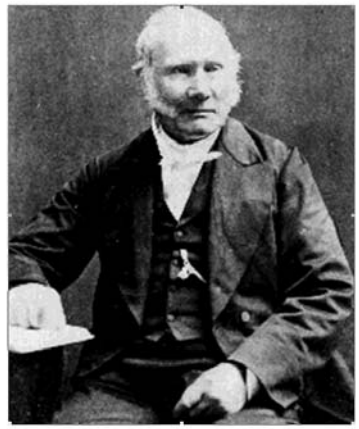
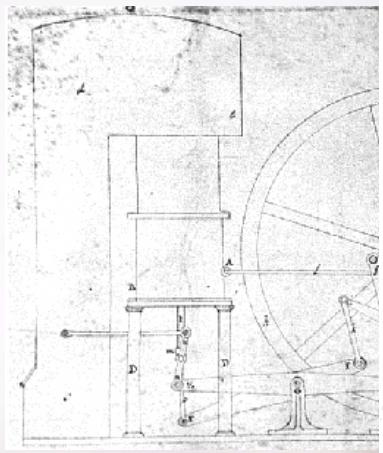
Robert Stirling

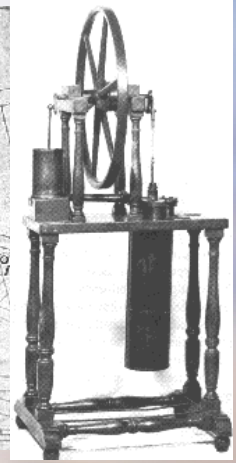
STIRLING

- Cycle invented by Robert Stirling
- Alternative to regularly exploding boilers of steam engines
- Refrigeration with same cycle first discovered on 1832
- Both engine and cold generator discarded due to practical manufacturing problems



Rev Dr Robert Stirling (1790-1878)





Revival

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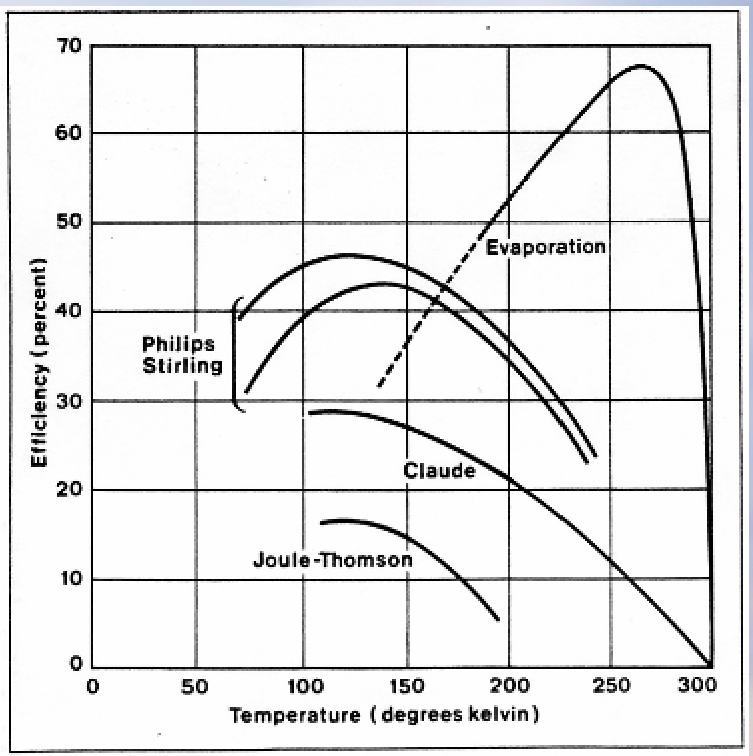
- **1938**

  Philips in need of power source for electricity generator for radiosets
  Dr. Rinia's attention falls on 120 year old Stirling cycle
- **1940 – 1945**
  Fuel shortage accelerates development
- **1948**
  Dr. Koehler requested to investigate refrigeration aspects resulting in development of cryogenerator

Stirling Cryogenerators

STIRLING

- Research proves high efficiency of Stirling cycle in cryogenic temperature range compared to others



Stirling Cryogenerators

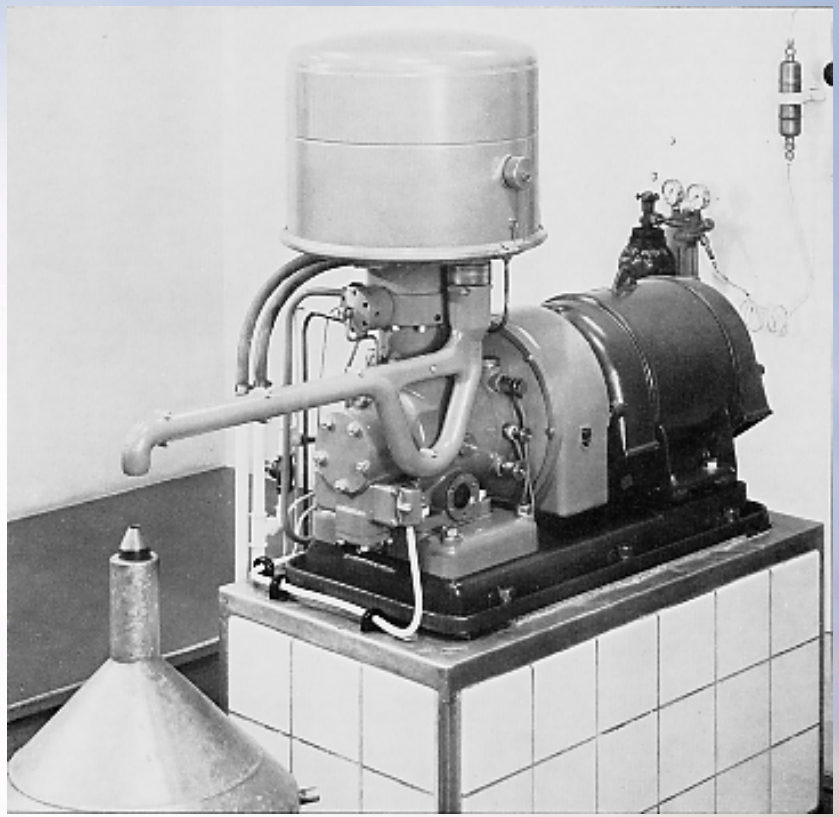
STIRLING

- Development and optimization of essential key element of Stirling cycle: **the regenerator**
- Temperature difference over approx 40 mm is more than 200 degrees
- High efficiency

Stirling Cryogenerators

STIRLING

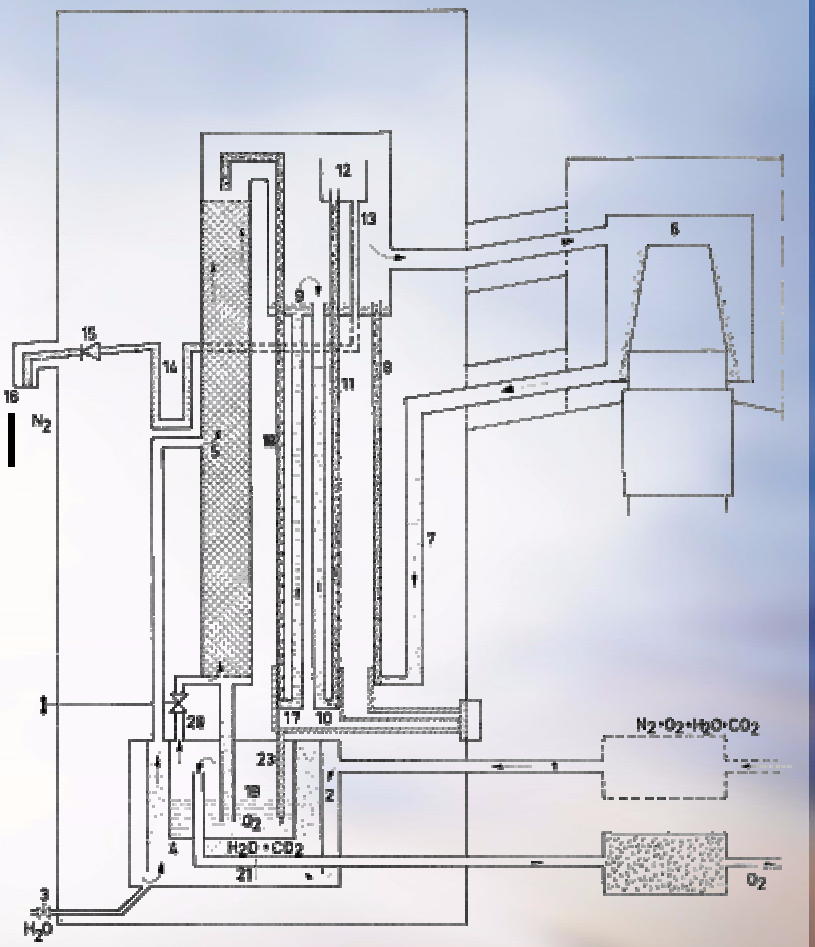
- 1953
  First commercial cryogenerator: liquid air system
- Immediate success
- Increasing demand for liquid nitrogen



Stirling Cryogenerators

STIRLING

- Development of compact air separation column
- Totally self regulating using thermo dynamical balance
- No moving part
- No electronic device
- Energy efficient = low LIN litre cost



Stirling Cryogenerators

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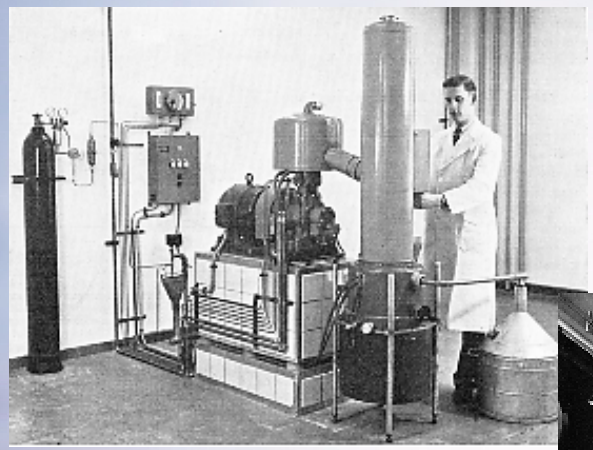
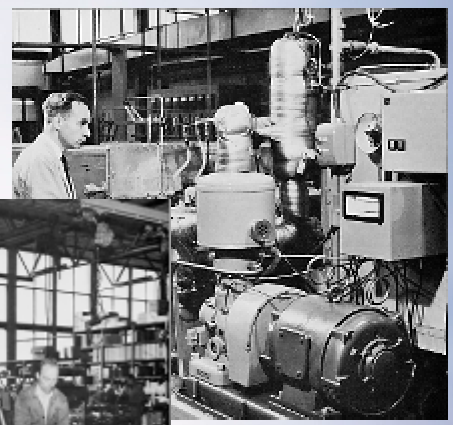
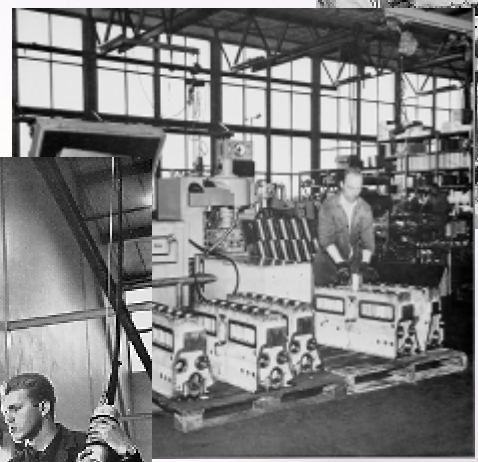
Reliable regenerator and air separation column result in explosive market success







Stirling Cryogenerators

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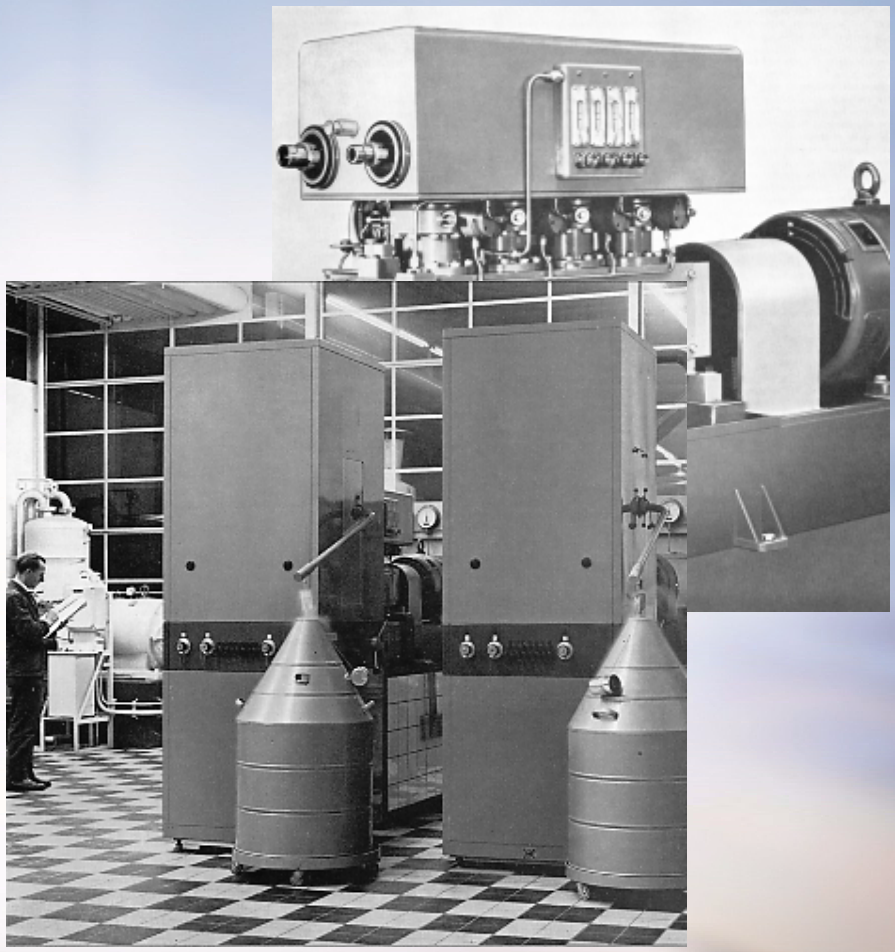
- 4 cylinder developed to meet increasing demand for cooling power
- High capacity air separation column developed to meet demand for LIN



Stirling Cryogenerators

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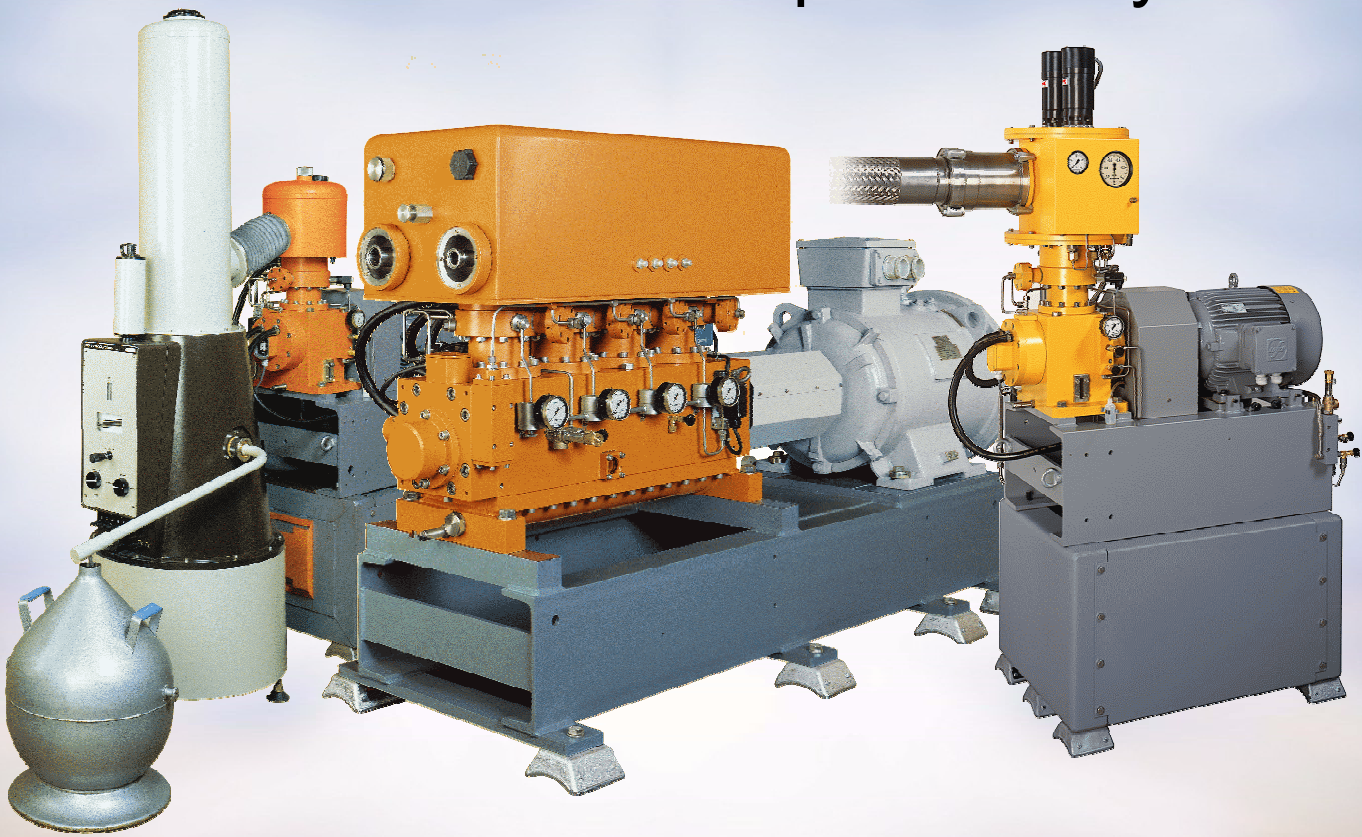
Success results in new optimized systems



Stirling Cryogenerators

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- Active Charcoal Pressure Swing Adsorption (PSA) replaces air separation columns and makes different capacities easily obtainable

Stirling Cryogenerators

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- Large range meets many demands

The Present Status

STIRLING

Improvements

- Mean time between maintenance increased to 8000 operating hours.
- The control system is digitised with text display of operating status.
- Incorporation of capacity control for power efficiency
- Compact framed structure – ease of installation

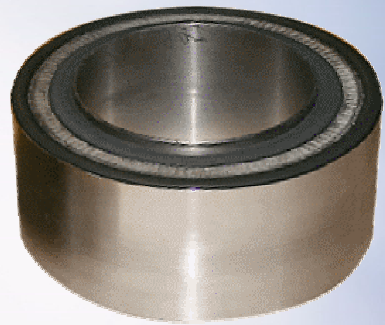
Ongoing research

STIRLING

- **Improving regenerators for even higher cold production**

Mid 50's – mid 80's
Glued paper based
Copper wire filling

Mid 80's – mid 90's
Stainless steel construction
Copper wire filling

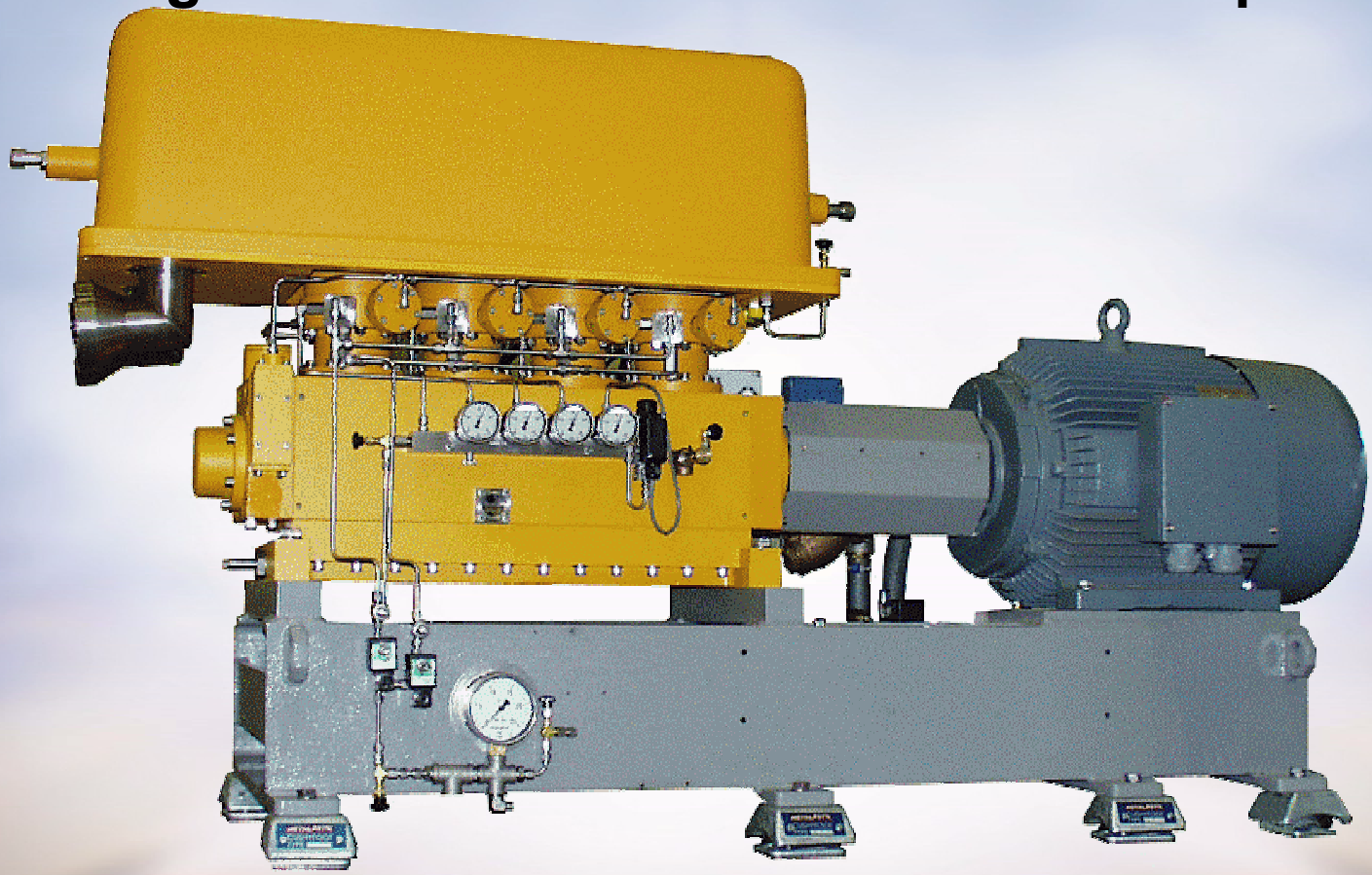


Mid 90's – now
Stainless steel construction
Sintered metal filling

Ongoing research

STIRLING

- High vacuum insulated head for more power



Ongoing research

STIRLING

- Improved chillers developed for rural areas with high temperatures
- Improvement in different maintenance related areas making maintenance easier and lowering operational cost
- Development of cold heat exchanger for specific application
- Oil free Stirling Cryogenerator.
- Stirling cycle based pulse tube for small capacity StirLIN plant.

The future machine of this decade

STIRLING

Cryosphere

- Magnetically driven dual piston system
- Low maintenance requirements
- Low power consumption
- Multi-purpose
- Compact and powerfull

On-going R&D projects

STIRLING

THE FUTURE LIQUID NITROGEN DISPENSER

StirLAB 200

Applications

STIRLING

Cryo Treatment of Metals

Why : Improvement of properties
like hardness, abrasion
resistance, life, dimensional
stability.

Process : Stirling Cabinets.

Supply : Philips H&ST Factory
The Netherlands
TNI, Thuringen, Germany

Applications

STIRLING

Cooling High Temp. Superconducting devices

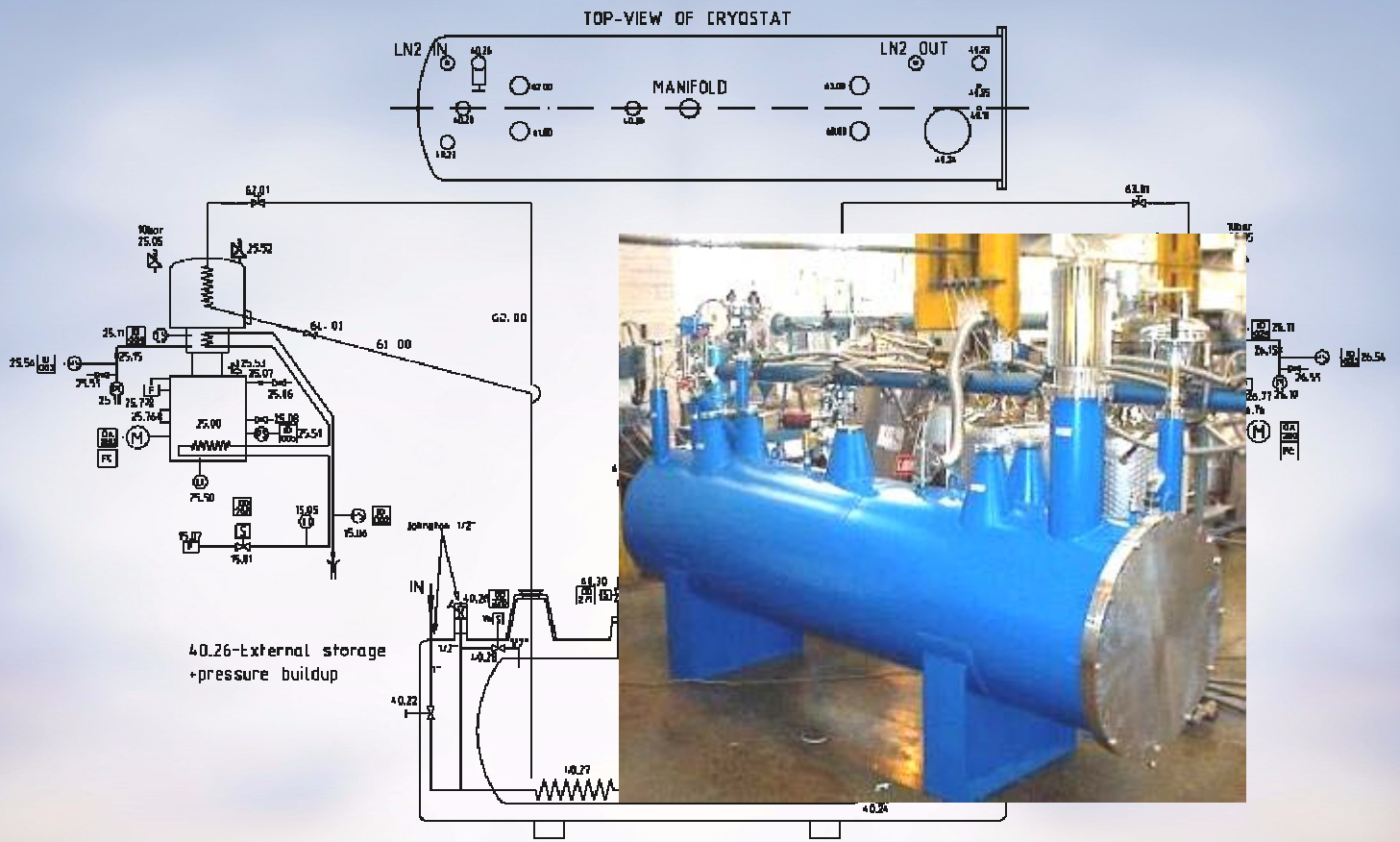
- With the invention and development of High Temp. Super Conductor over last decade, cooling temperature requirement got changed from 4K to 65K or higher.
- Achieving 65K can be through ;

  *sub cooling liquid nitrogen

  *boiling nitrogen at sub atmospheric pressure.

  *combination of boiling & sub cooling.
- Option depends on specific requirement of application

Applications



Hybrid Cooling System from Stirling NKT/DTU, Denmark

Applications

- Artificial insemination
- Medicine
- Inerting
- Space
- Aeronautics
- Metal treatment
- Nuclear
- Food production and preservation
- Experimental physics
- Etc……

Conclusion

STIRLING

Robert Stirling's invention has lead to a successful cryogenic business!

Stirling Cryogenics & Refrigeration BV

Mission:

To provide low temperature cooling, where you need it, when you need it.

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