

Side-Event 2015-04-22

Development of commercial refrigeration concepts with CO₂ as refrigerant for hot climates

Petter Neksa

Petter.Neksa@sintef.no

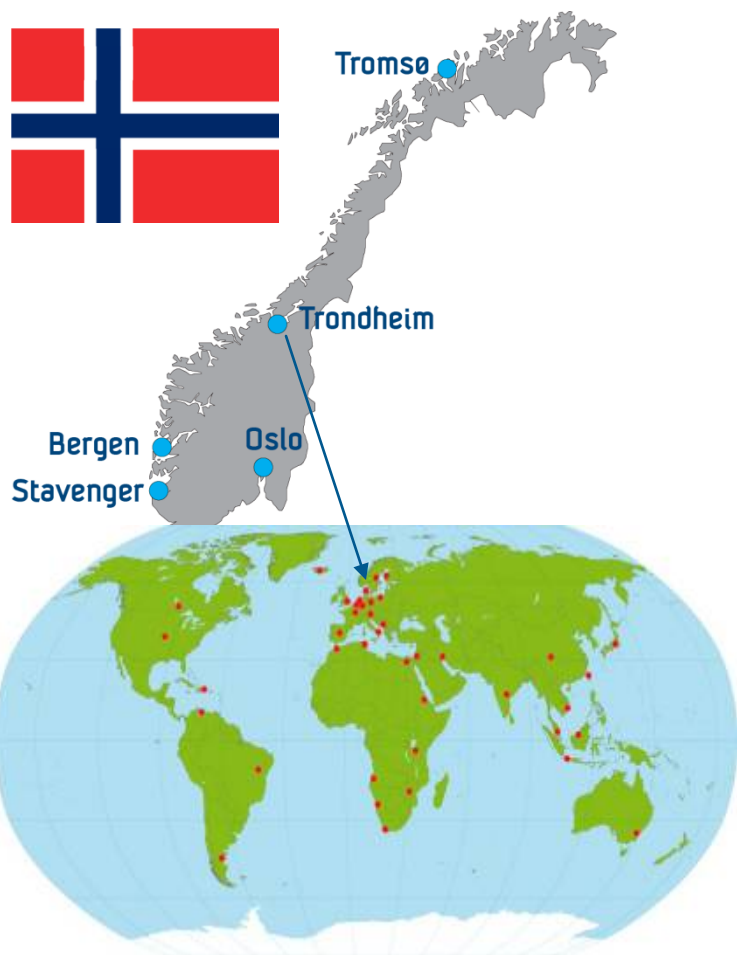
Chief Research Scientist, SINTEF Energy Research

Adjunct Professor at NTNU, Dept of Energy and process engineering

Visiting Professor at Doshisha University, Energy Conversion Research Center, Kyoto

SINTEF - A contract research organization based in Trondheim, Oslo, Bergen, Stavanger and Tromsø

- SINTEF is one of the largest independent research organisations in Europe.



Social perspective

SINTEF wishes to contribute to the creation of value and to a society in healthy sustainable development.

Business concept

SINTEF sell research-based knowledge and related services to Norwegian and international clients.

Fundamental values

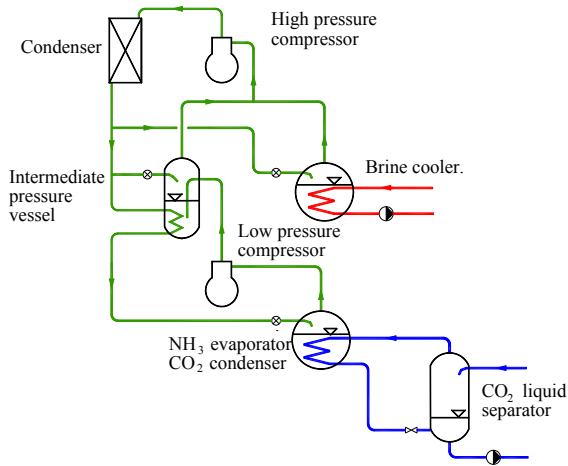
Honesty, Generosity, Courage and Unity

SINTEF has 2145 employees, 1600 situated in Trondheim and 430 in Oslo.

CO₂ for commercial refrigeration, disc early 1990s

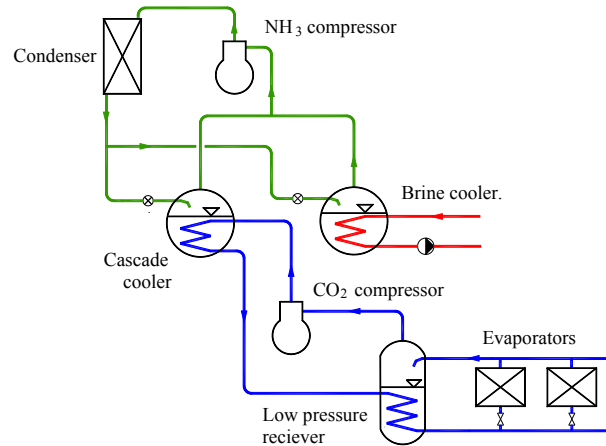
Largest refrigerant GHG emissions of the refrigeration sector, more than 40% of the CO₂-eq emissions

CO₂ as heat transfer fluid



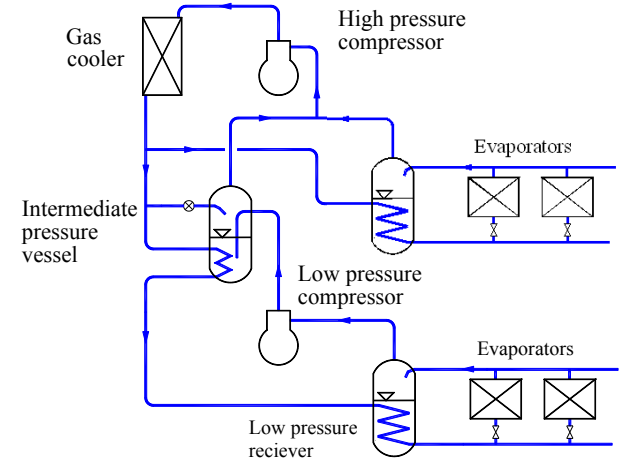
- General scepticism to CO₂
 - pressure
 - efficiency
- However
 - Reduced pumping power LT
 - Retrofit R22
- Rolfsmann 1995?

CO₂ in low temp cascade stage



- Good arguments for CO₂ LT stage
 - No pump
 - Reduced swept vol
 - Standard pressure level
- And
 - Very efficient compression
- Norild 1993

CO₂ transcritical / (subcritical)



- Why not all-CO₂?
- Benefits
 - One refrigerant
 - Small dimensions
 - Less costly?
- Status
 - Several supermarket chains and manufacturers has decided for CO₂

The first field test CO₂ commercial refrigeration centralised system, 1999 and status now

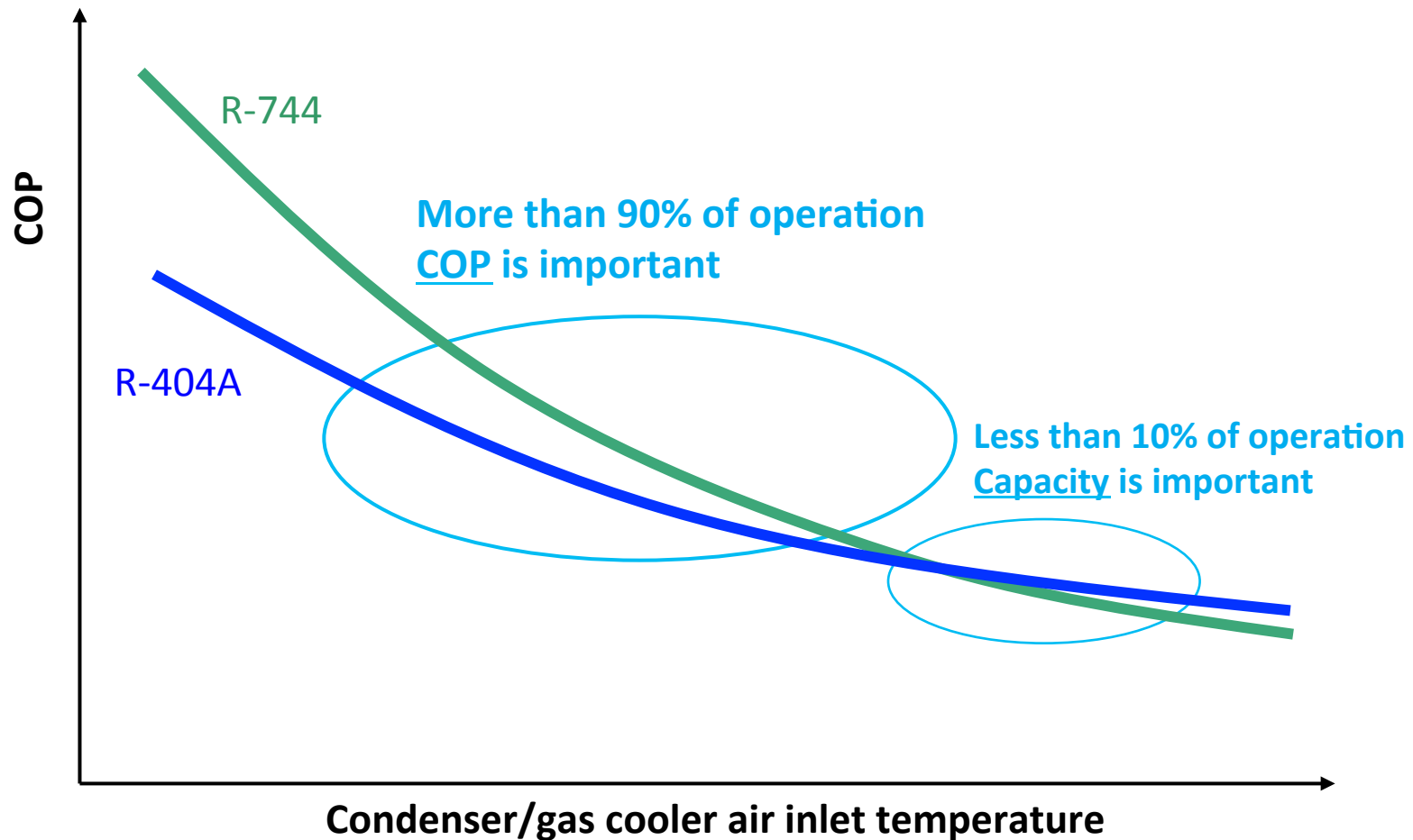
Field test system in Belluno, Italy 1999



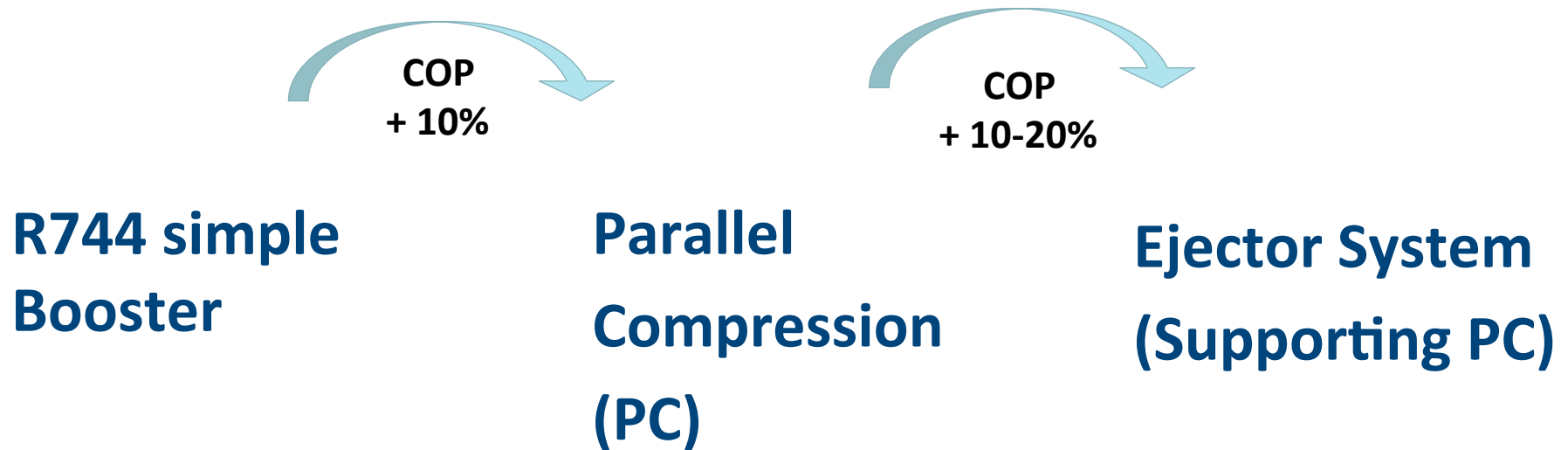
Centralised system
Nominal cooling capacity 11 kW
Medium temperature (-10°C)
Heat rejected to liquid loop
Dry cooler on the roof
Preliminary COP 2.4 at 30°C amb

- More than 4000 supermarkets in Europe with transcritical CO₂
- 10 kW to 1 MW
- Systems have been installed also outside Europe
- What about hot climates?
 - Too low efficiency with CO₂ or?

Typical efficiency at varying condenser/gas cooler air inlet temperature, simple cycle system



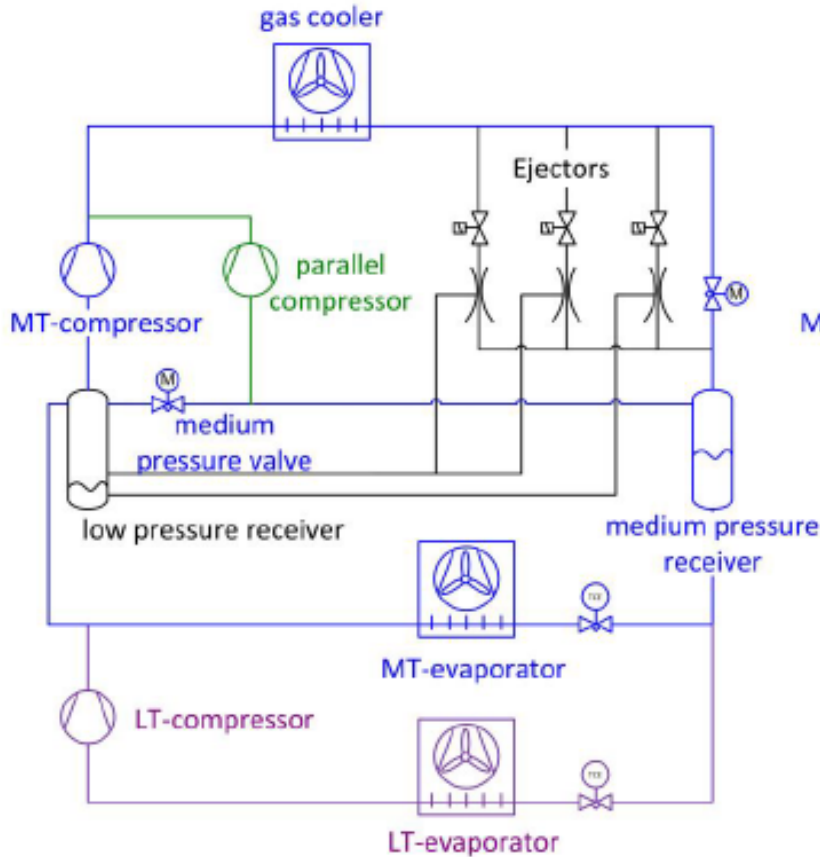
Evolution of CO₂ Commercial Refrigeration systems (Supermarkets)



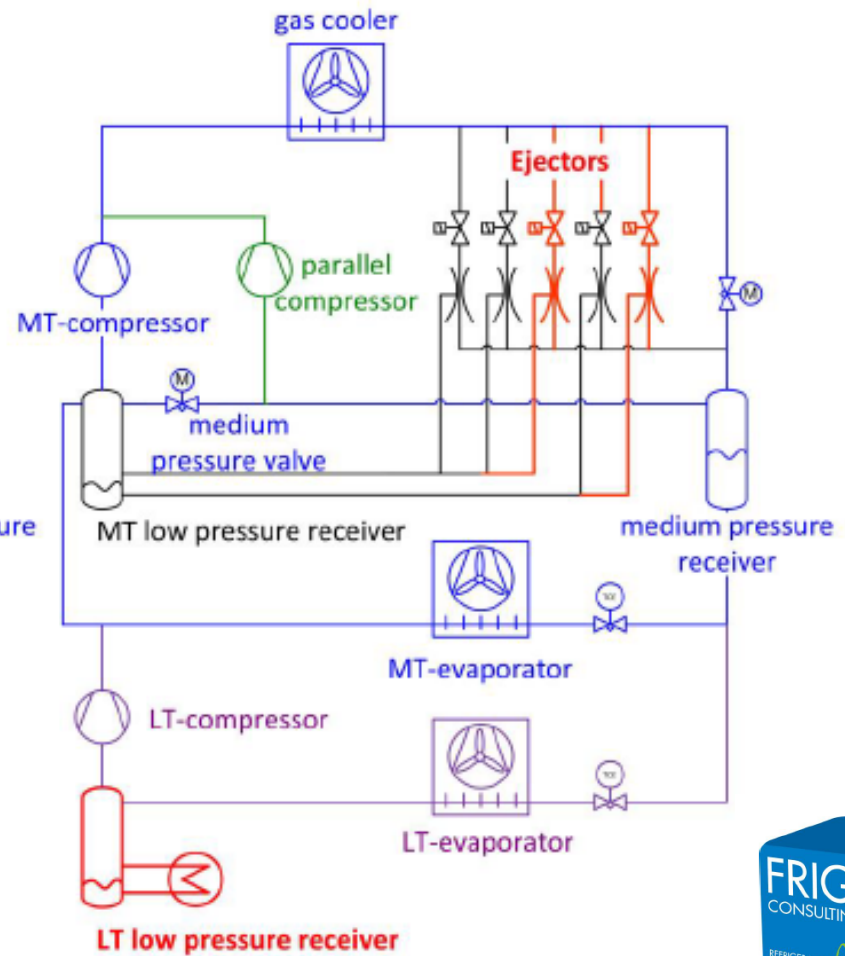
Verification at high ambient temperatures are ongoing

Example: 'Multi Ejector' Supermarkets in CH

Migros Bulle



Migros Ibach



Ref: Eric Wiedenmann, ATMOsphereEurope 2015

Multi-Ejector block

- Compact design,
made in cooperation
with Danfoss
- Six fixed geometry nozzles
- 6-100 kW cooling capacity

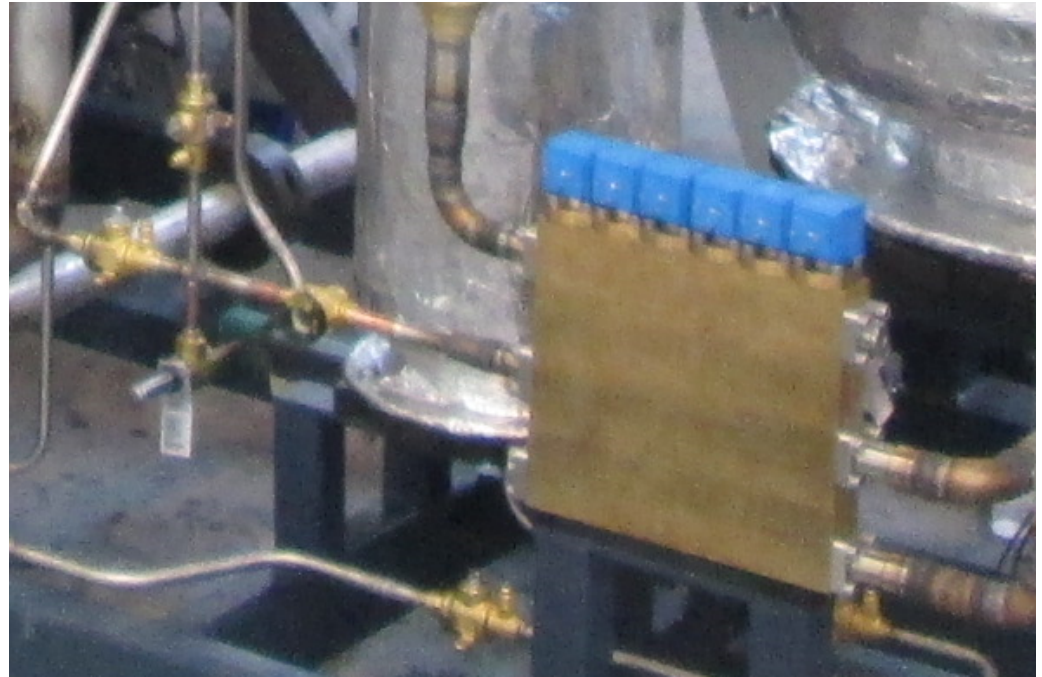


Photo: Enex srl www.enex.it



CO₂ applications, status transcritical

- **Already developed and commercialised**
 - Heat pump water heaters – domestic, commercial and industrial sized
 - Commercial refrigeration systems, supermarkets
 - Beverage coolers
 - Ice cream chest freezers
 - Water chillers for moderate climates, air conditioning and industrial
 - Transport refrigeration (bus, train)
- **Already developed – not yet commercialised**
 - Mobile air conditioning systems
- **Under development or field test**
 - Mobile heat pumps
 - Transport refrigeration systems (containers, truck, marine)
- **Under development or field test, contd**
 - Residential heat pumps (space heating and reversible)
 - Vending machines for combined hot and cold beverages
 - Combined heating and cooling of non-residential and residential buildings
 - Heat pumps for space heating and combined space and water heating
 - Heat pump dryers of residential and commercial size, e.g. laundry applications
 - Rankine power cycles for utilisation of low temperature surplus heat
- **Under early development**
 - Residential air-conditioning systems
 - Water chillers for hot climates, air conditioning and industrial
 - Industrial refrigeration and heat pumps

Summary / conclusions / outlook

- Tremendous development of CO₂ technology since 1988
- Energy- and cost efficient CO₂ systems have been introduced in the market
- Adapted ejector technology in combination with parallel compression offer high system performances and COP's also at **high ambient** temperatures
- CO₂ is a viable natural refrigerant PHASE-IN candidate for many applications, globally

CO₂



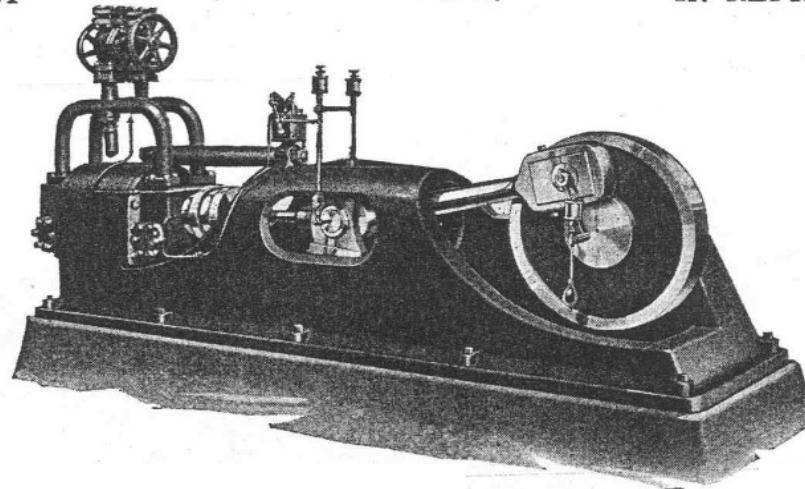
REFRIGERATION

CARBONIC SAFETY SYSTEM

MEANS BEST

(REG. U. S. PAT. OFF.)

IN REFRIGERATION



American Carbonic Machinery Co.

WISCONSIN RAPIDS, WISCONSIN

NEW YORK
30 CHURCH STREET

CLEVELAND
65TH AND EUCLID AVENUE

CHICAGO
1631 MONADNOCK BLDG.

ST. PAUL
43 W. 4th STREET

CARBONIC

SAFETY

SYSTEM

(ICE and REFRIGERATION, 1922, vol. 63)