

Centrifugation: past and present



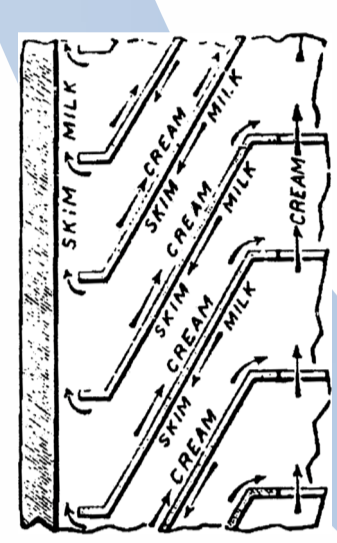
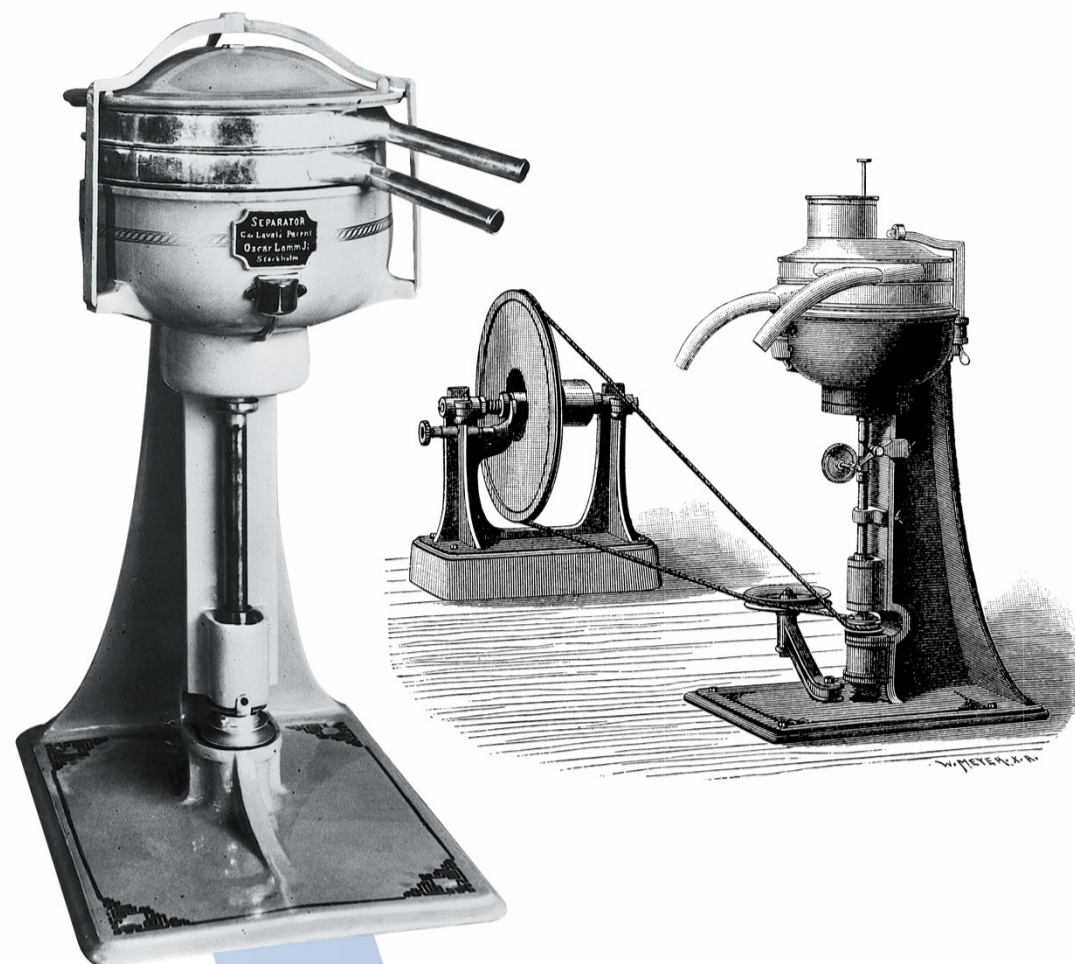
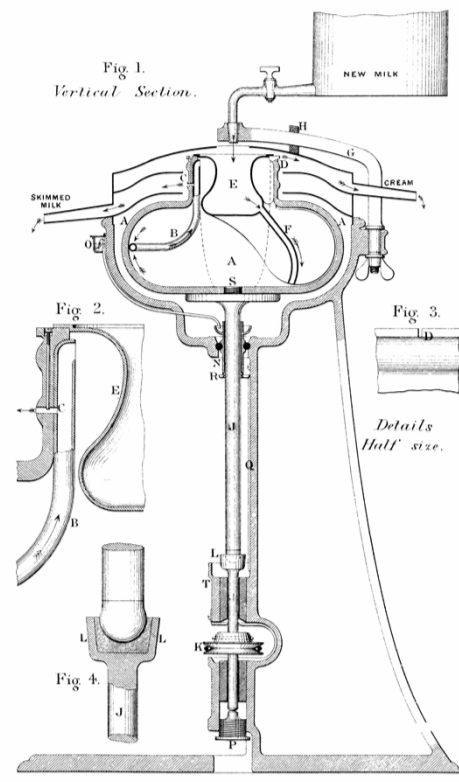
Simon Nordestgaard

The Australian Wine Research Institute, PO Box 197, Glen Osmond (Adelaide) SA 5064, Australia

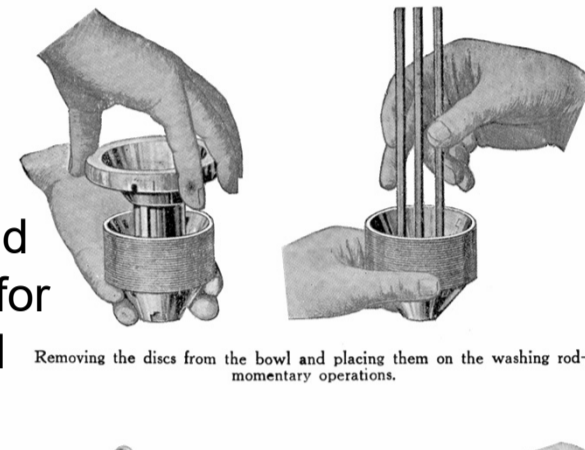
Corresponding author's email: simon.nordestgaard@awri.com.au

Continuous centrifugation of milk

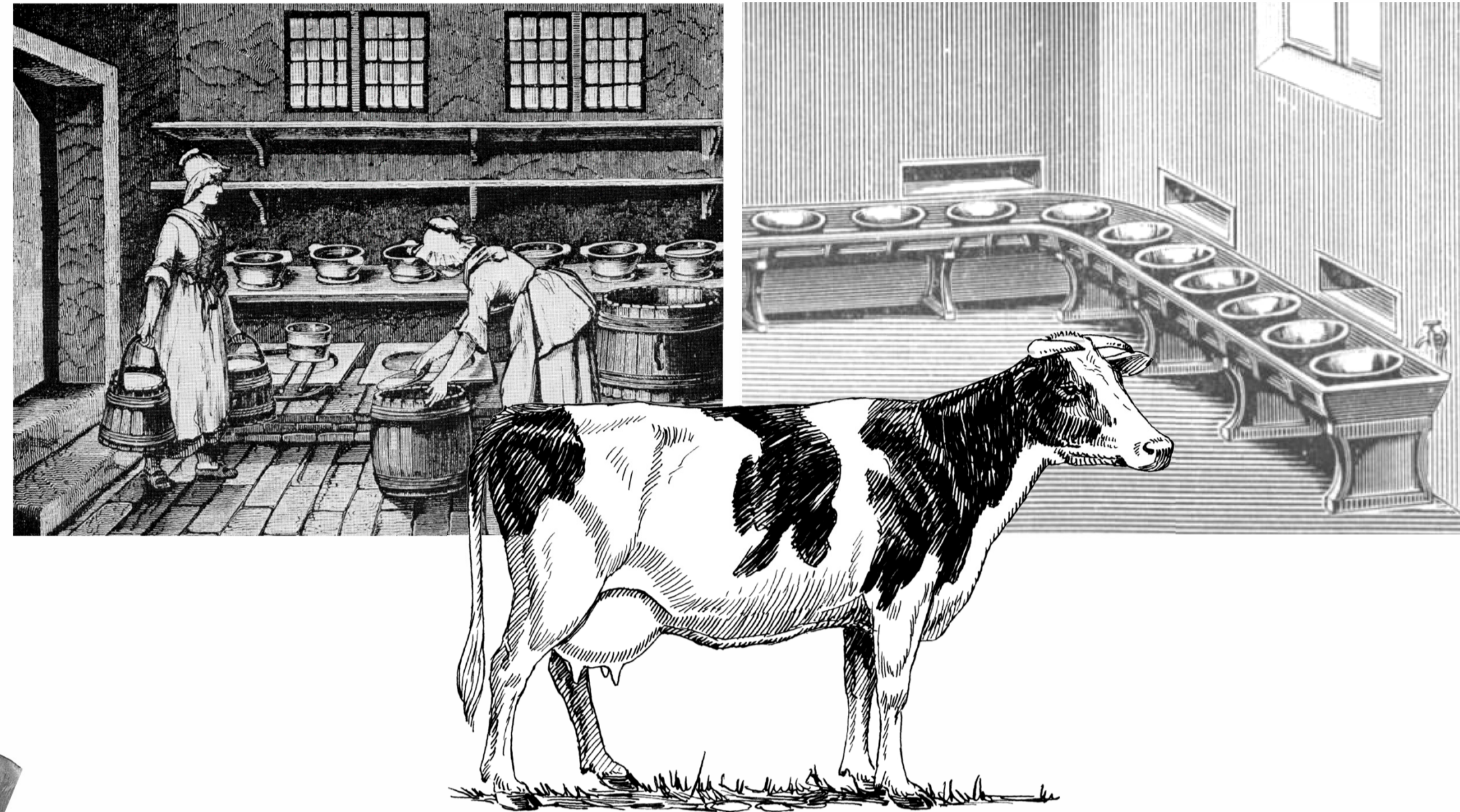
Gustav de Laval invented the continuous centrifugal separator in Sweden. It was a big improvement on gravity separation for milk. The dairy industry is still one of the biggest users of centrifugal separators.



Operation and disc cleaning for a later small centrifuge

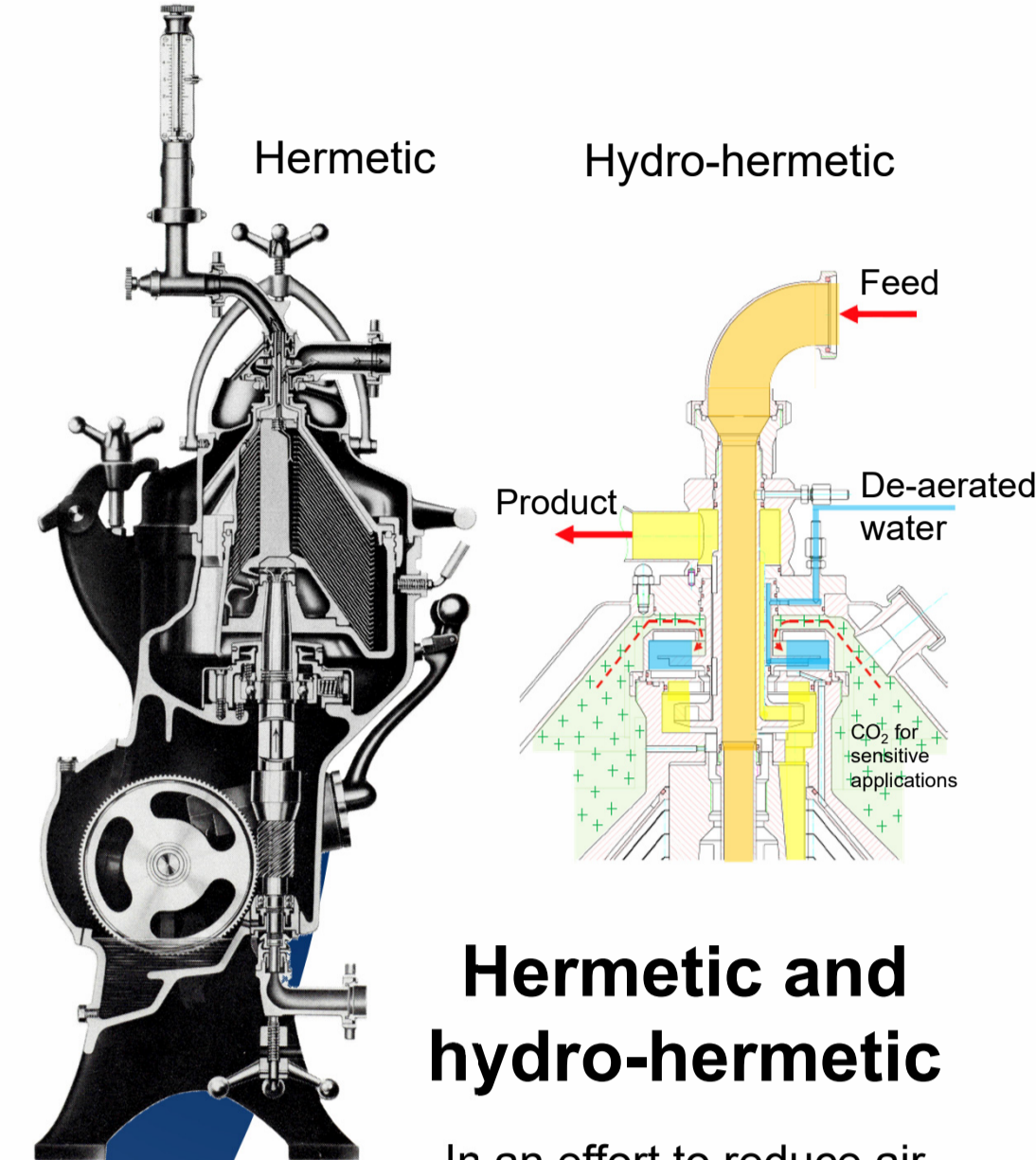


Working on discs the disc all together.



Gravity separation and skimming of cream

Before the advent of the centrifugal separator, cream was allowed to rise in bowls and was then manually skimmed. This was often done in dedicated rooms and later in cold water baths. It was a very inefficient process.



Hermetic and hydro-hermetic

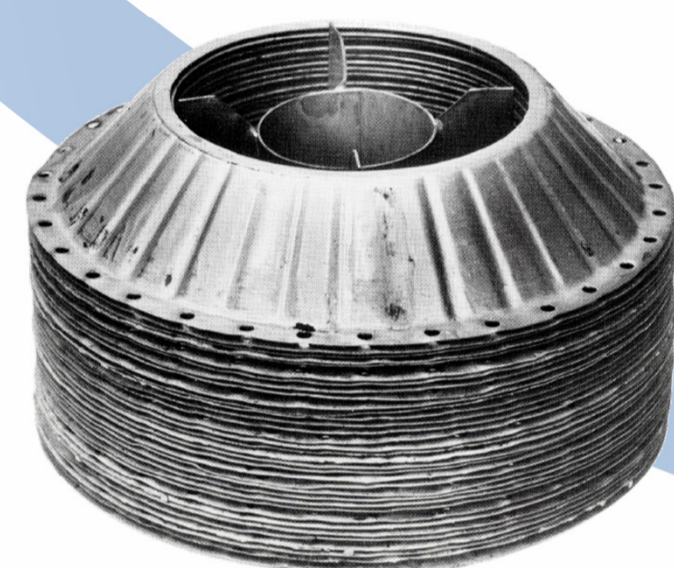
In an effort to reduce air contact, bottom fed hermetic centrifuges were introduced. Alternate designs with top-feeding and water seals and optimised feed distributors were also released (this is now the most common arrangement in winery centrifuges)

Paring disc pump

Foaming of protein-rich liquids when agitated in contact with air had always been an issue with centrifuges. The introduction of the paring disc helped to alleviate this somewhat and also provided an in-built static pump by converting the rotational energy into pressure.

Von Bechtolsheim's Alfa discs

A German inventor patented a variation to centrifugal separators whereby a stack of discs would be mounted in the separator bowl. This created lots of thin layers minimising the distance that each phase would have to travel. AB Separator (now Alfa-Laval) acquired the rights and with these discs their machines more than doubled in capacity for the same bowl size. Discs are used in machines to this day.



Dairy origins

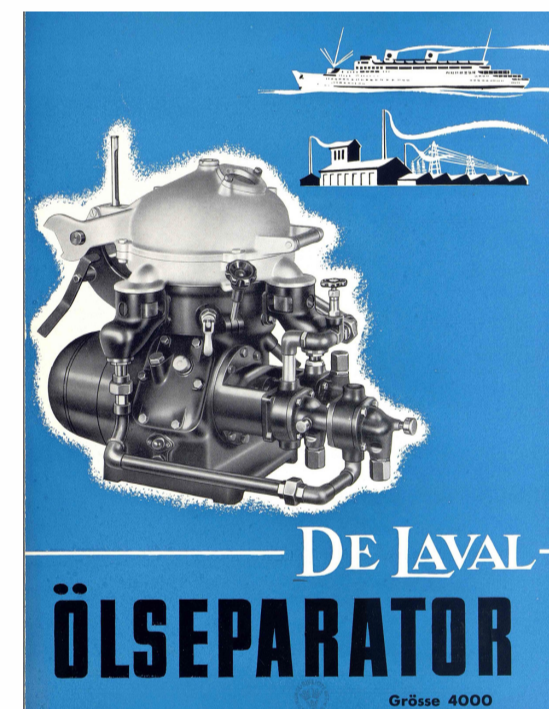


Hand-driven separators

Hand-driven separators had been sold before the introduction of the disc-stack, but sales accelerated massively after their introduction. The Alfa 'Baby' shown became the first big seller. Before the introduction of the discs it could skim 50 L/hr, after the discs it could skim 125 L/hr, and with subsequent improvements it could skim 250 L/hr.

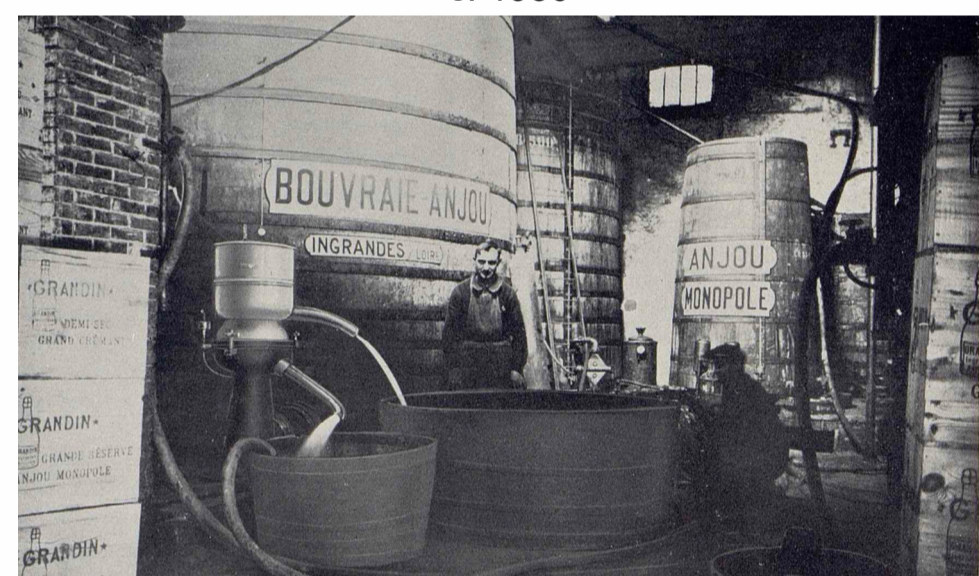
Centrifuges are used in many industries

In terms of overall sales, wine is a very small market for centrifuges. The biggest markets are dairy and marine applications (removing contaminants from fuel oil that could damage ship engines).



Wine industry beginnings

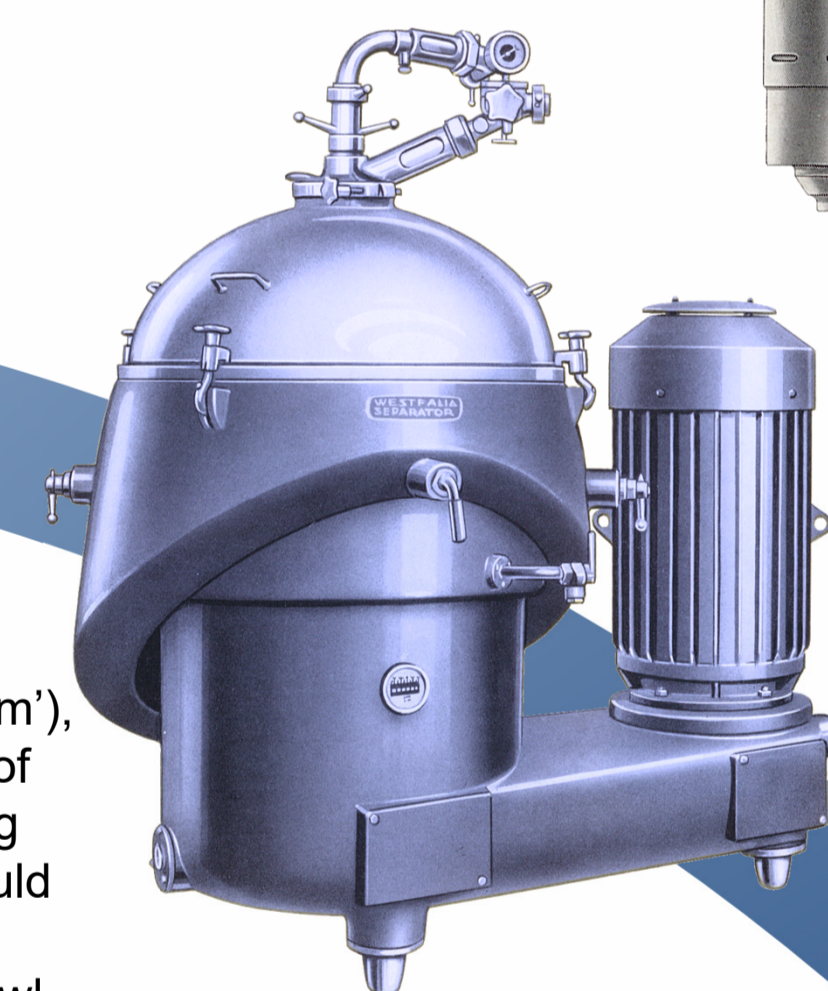
Some early centrifuges in the wine industry continuously discharged lees via nozzles. The process was very oxidative and the lees quite thin and the manufacturers recommended that the lees be reprocessed through the centrifuge once or twice more.



Wine industry

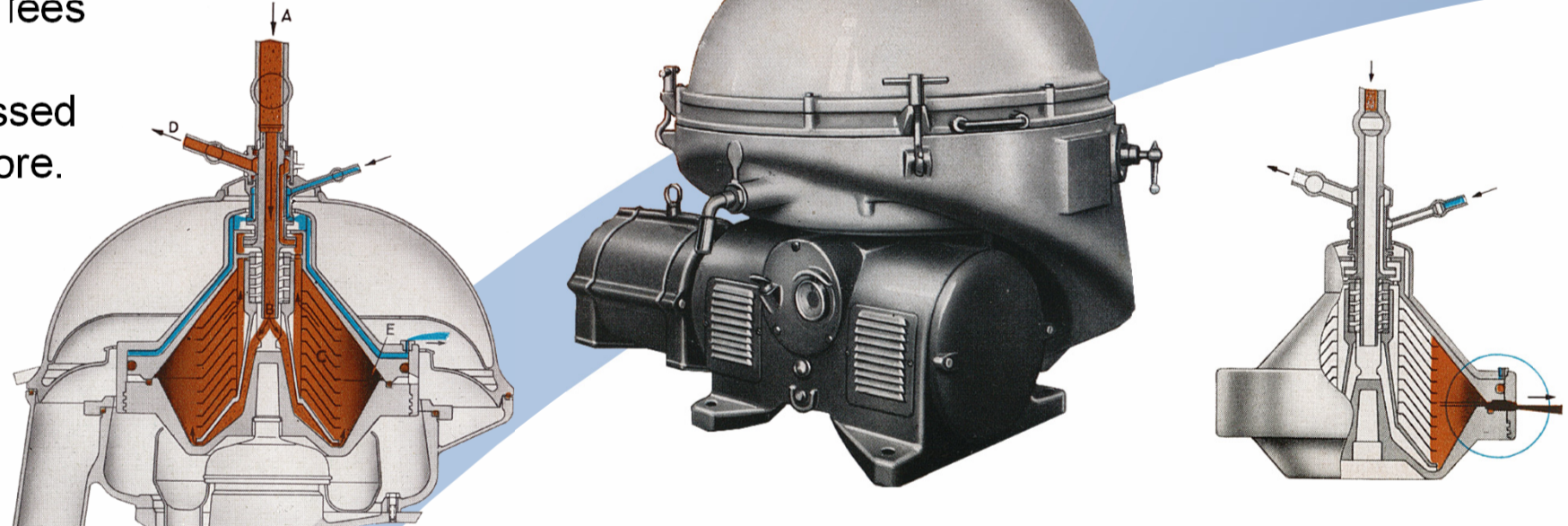
Partial discharges

In this SAMN design (a variant of which was affectionately known in Australia wineries as 'Big Sam'), operating water was required for opening instead of closing the bowl. To perform a desludge, operating water would flow above a moving piston, which would in turn push down a section covering the lateral openings. In this model, the opening time of the bowl could be reduced, resulting in a partial discharge (mainly sludge evacuated, not the total liquid in the bowl), subject to sludge consistency.



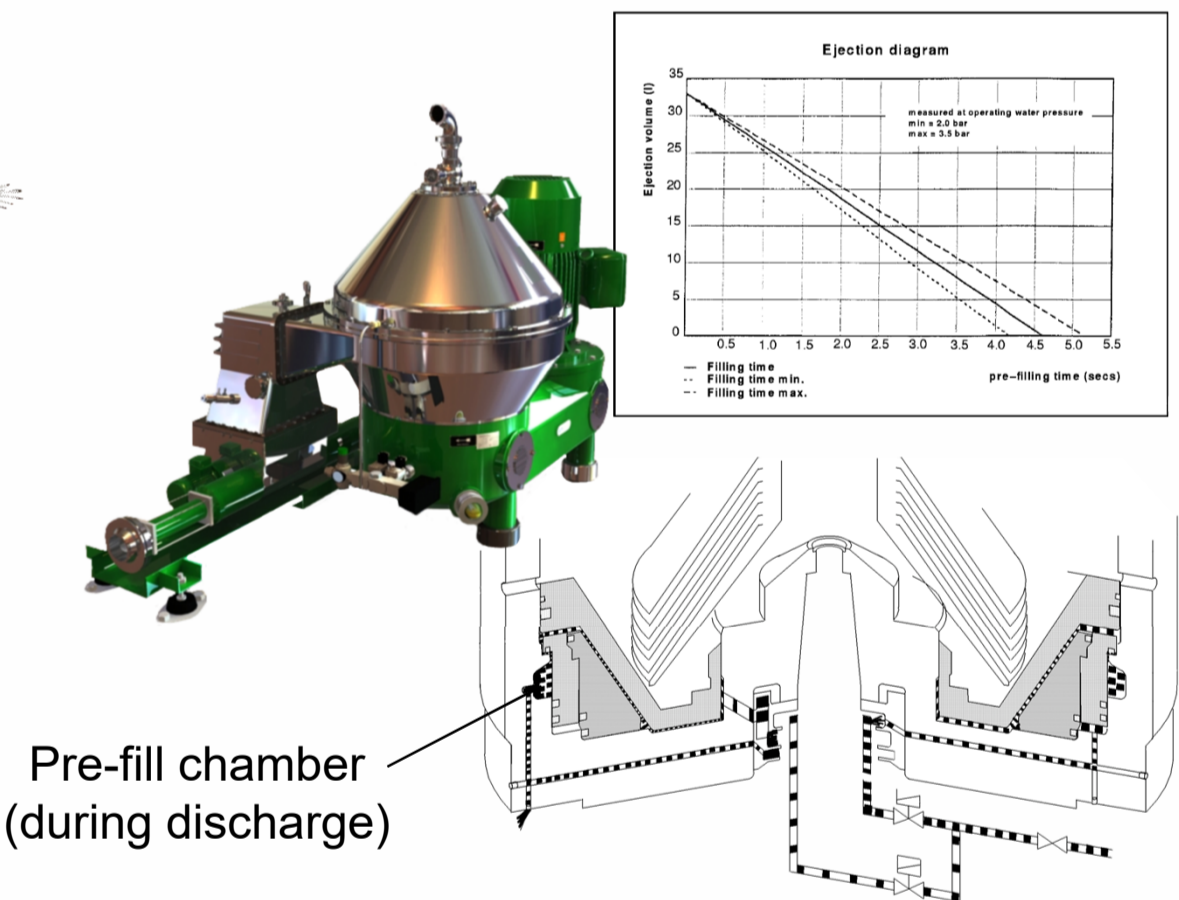
Self-emptying centrifuges

Self-emptying centrifuges removed the need to manually open and clean the centrifuge. The top of the chamber can move up and down. A flow of operating water above the top of the chamber keeps the bowl closed, but when this water is stopped, the top of the bowl lifts and there is a total discharge of the bowl (liquid and sludge), before restarting.



High speed partial discharges

In the Westfalia SC150 that has been so commonly used in Australian wineries, the bowl is kept closed by water under the moving bottom section. A chamber is filled with water to a desired level (based on a water filling time). This pre-fill volume/time sets the ejection volume, because during a discharge the water from under the moving bottom of the bowl is emptied into the pre-fill chamber and the bowl closes again as soon as that chamber is full. The ability to perform very fast accurate discharges allows for sludge with very high solids content, even when a relatively small amount of sludge has accumulated.



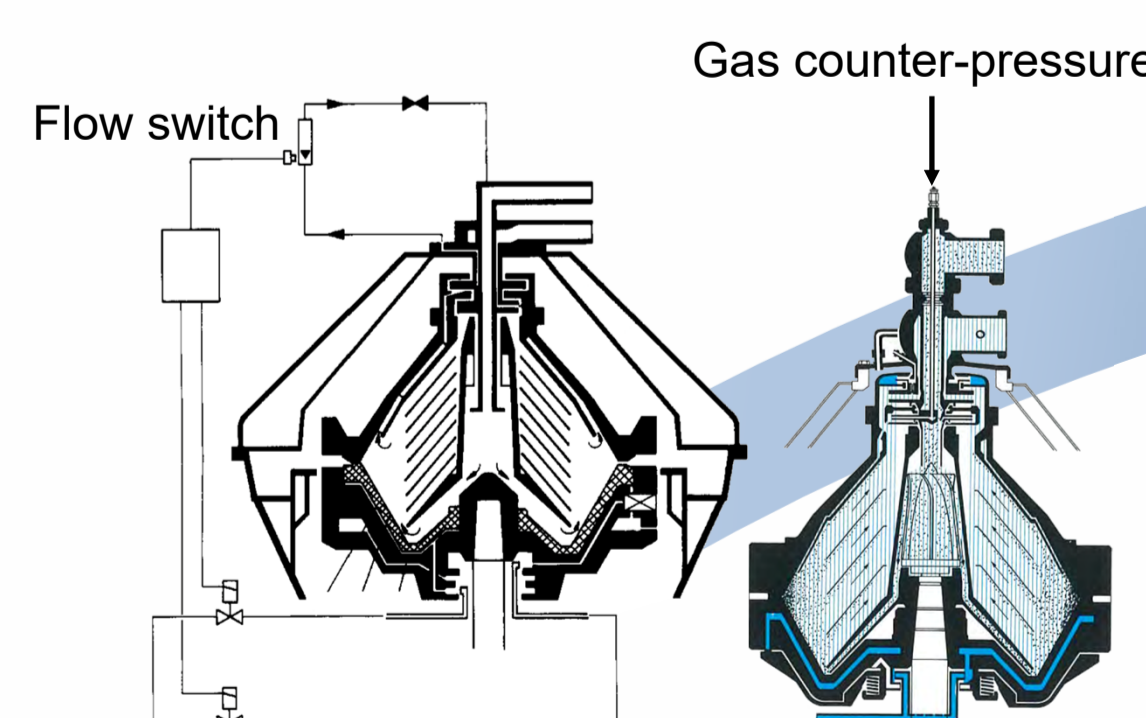
Chamber bowl centrifuges

Chamber bowl centrifuges allowed sludge thicker than was possible with nozzle centrifuges. The wine passed through multiple chambers where solids could be separated and accumulate on the walls. When the solids holding spaces were full, the centrifuge needed to be manually opened and cleaned, which was time-consuming and cumbersome.



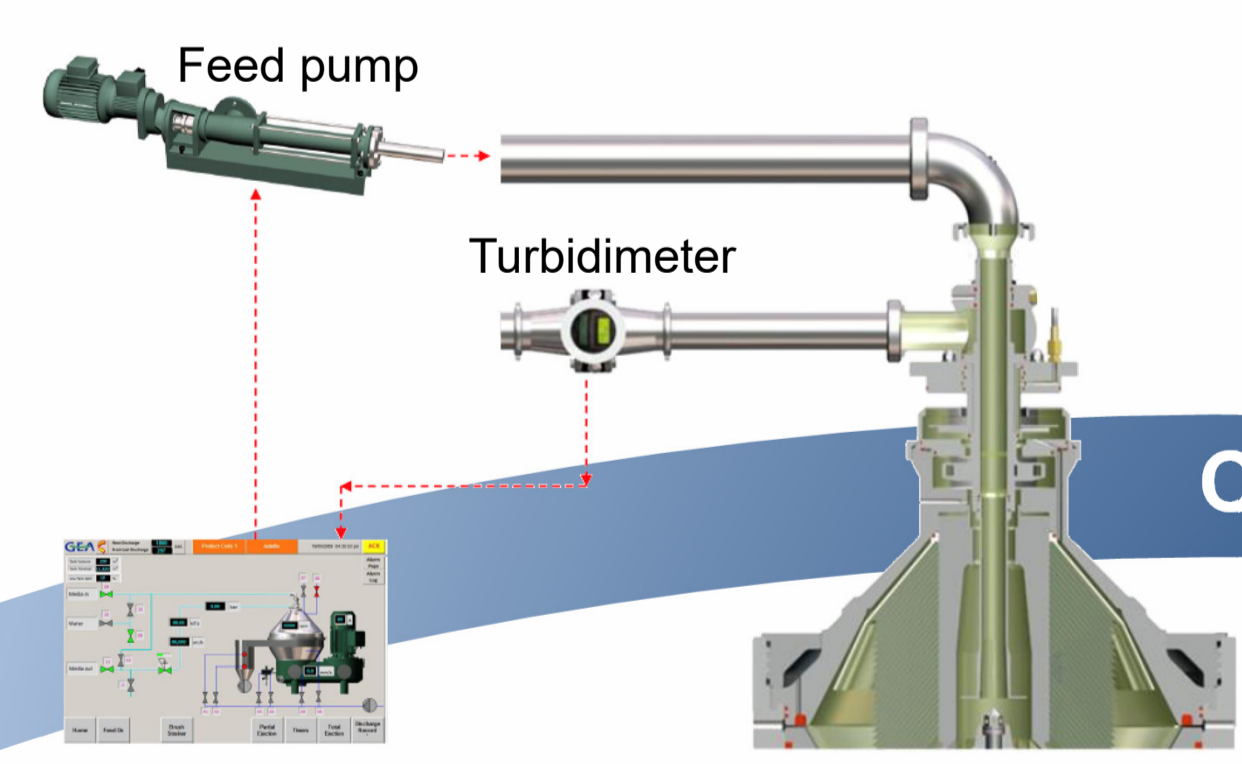
Discharge control from flow at the edge of the sludge holding space

Material from the edge of the sludge holding space flows above an extra larger disc on the stack through a sensor and back into the feed stream. When sludge builds up in the bowl and begins to flow above the disc the flow rate decreases and this is sensed by either a flow switch (Westfalia Self-thinker) or the decrease in counter-pressure of a supplied gas (Alfa-Laval EPTe) and a discharge is triggered. There can be problems with clears channelling through the sludge in some applications when the sludge holding space is full.



Turbidity-based discharge and capacity control

Turbidity measurement was a more reliable way of centrifuge control. When the sludge holding space filled up, solids would start to overflow into the product, triggering a discharge. The turbidity before the sludge holding space filled has also been used to control and maximise flow rate for a desired clarity level.



Sludge solids optimisation ?

Modern centrifuges are able to perform very fast quite small discharges with very high solids content. However, anecdotally, they are often not operated in this manner and sludge is ejected with lower solids contents, because safely running at very high solids contents with low solids content feeds requires very close monitoring by operators (who are often performing other jobs at the same time). Often machines fitted for discharge based on product turbidity are operated just on a timer. There is an opportunity for improved automation that would allow centrifuges to always run safely at high sludge solids levels. One barrier to realising this is that there is not currently a good way of measuring solids concentration in-line (instead of relying on spin tests). Developments on this topic would be of value to all winery clarification equipment (cross-flow filters, etc.). Solids content measurement of winery sludges is inherently difficult because it is hard for light to pass through them, because juice contains sugars that contribute to density and caramelise on heating and because of the inclusion of liquid in cellular structures.

Integrated direct drives

There is increasing interest in reducing electricity use and therefore the larger centrifuge manufacturers have developed machines with integrated direct drives that have slightly lower energy losses compared with gear- or belt-driven machines and also have a smaller footprint.

