

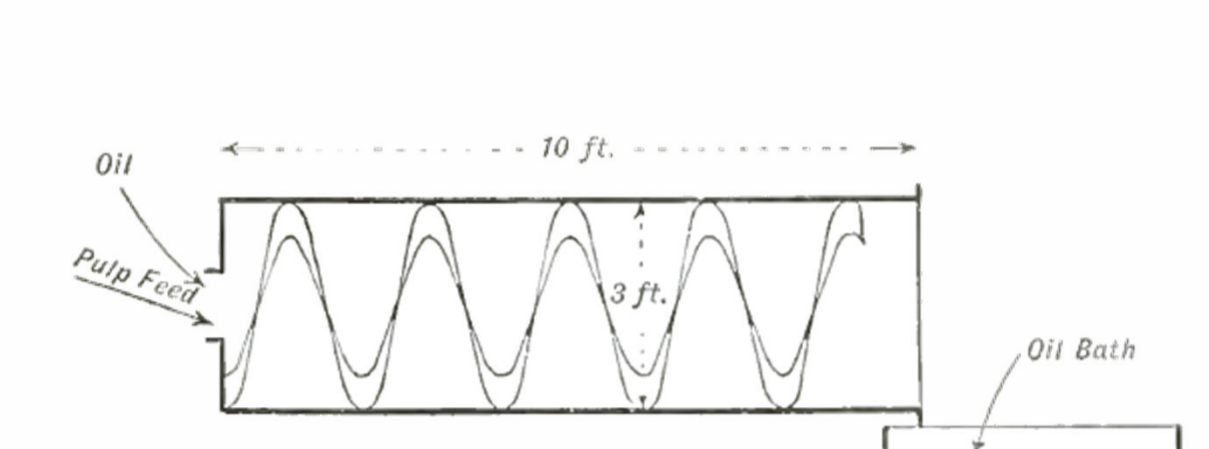
# Flotation: past and present



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## Bulk oil flotation

Early flotation processes typically relied on oil for flotation rather than bubbles. Hydrophobic mineral constituents of interest were attracted to the oil and recovered (Elmore 1898 bulk oil process shown). In 1877 the Bessel brothers were the first to patent the use of bubbles for separation - oil was still used and bubbles were generated by boiling in their graphite separation process.

## Vacuum flotation

The Elmore vacuum technique relied on both oil and bubbles for flotation, with the bubbles being generated courtesy of a vacuum.

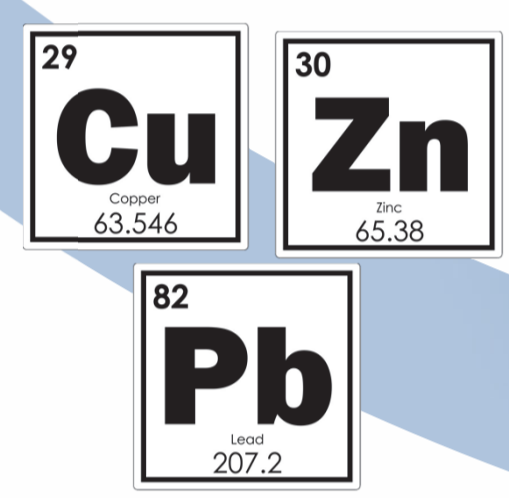
## Potter-Delprat flotation

This process relied on the inclusion of carbonates in the feed that generated bubbles when treated with acid. This process was developed in Australia, which played a key role in the development of minerals flotation techniques in the early 20<sup>th</sup> century.

	Minerals	Wastewater	Grape juice
<b>Primary aim</b>	Minerals separation	Removal of solids	Removal of solids
<b>Most valuable phase</b>	Floats	Clears	Clears
<b>Need for low liquid content in floats</b>	Moderate	Moderate	High
<b>Risks of using air instead of N<sub>2</sub></b>	Low	Low	Medium - ok for hyperox.
<b>Ability to add chemicals</b>	High	Moderate	Low
<b>Batch sizes</b>	Large	Large	Small
<b>Number of products</b>	Few	Few	Many

## Flotation – a major development in all three industries

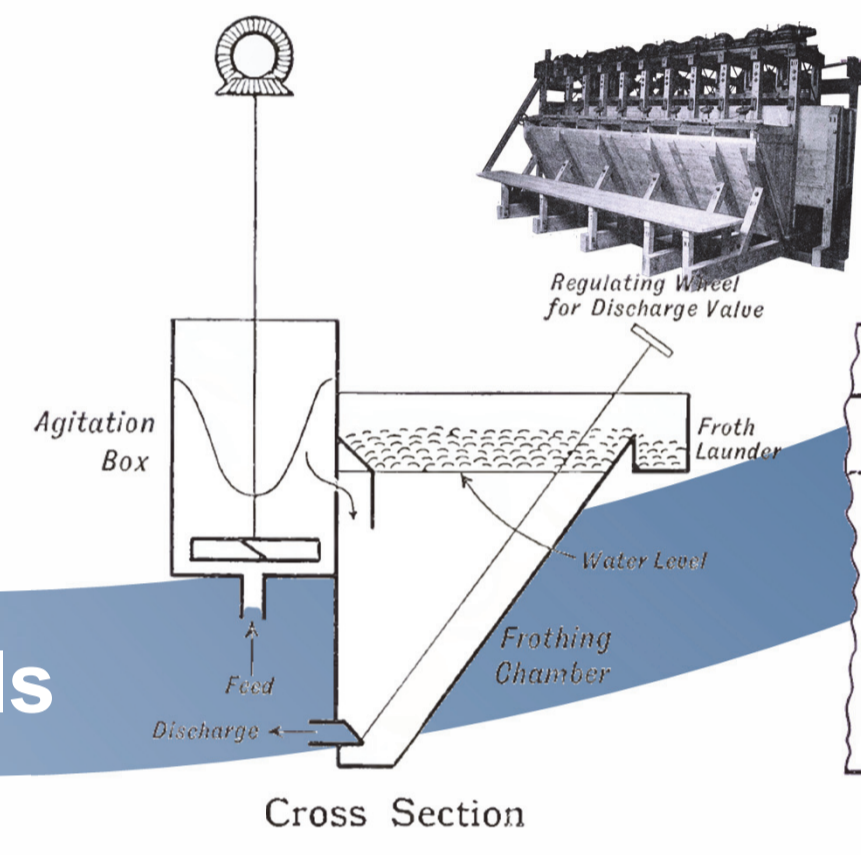
Flotation has allowed valuable minerals to be recovered, higher throughput water/wastewater clarification and faster clarification of grape juice without refrigeration and with less juice occlusion in the lees than with settling. Each industry has its own peculiarities that influence which flotation techniques are most appropriate.



## Chemicals

Chemicals play a critical role in allowing the efficient separation of different minerals by flotation, even more so than in other sectors. They are categorised as frothers, collectors, activators, depressants, modifiers and flocculants.

## Minerals

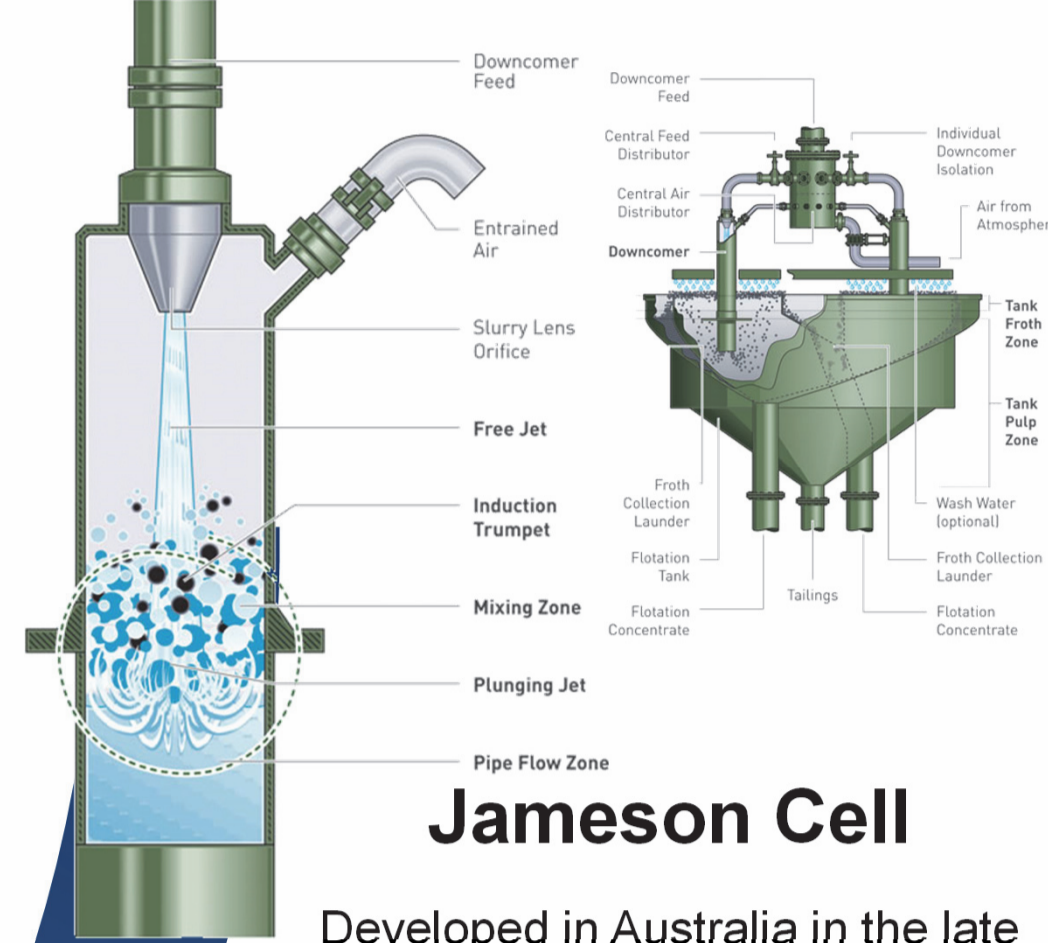


## Mechanically agitated flotation cells

Mechanically agitated cells rely on agitation to entrain air into the pulp mixture. A multistage system is shown, with the discharge from each stage feeding the subsequent stage.

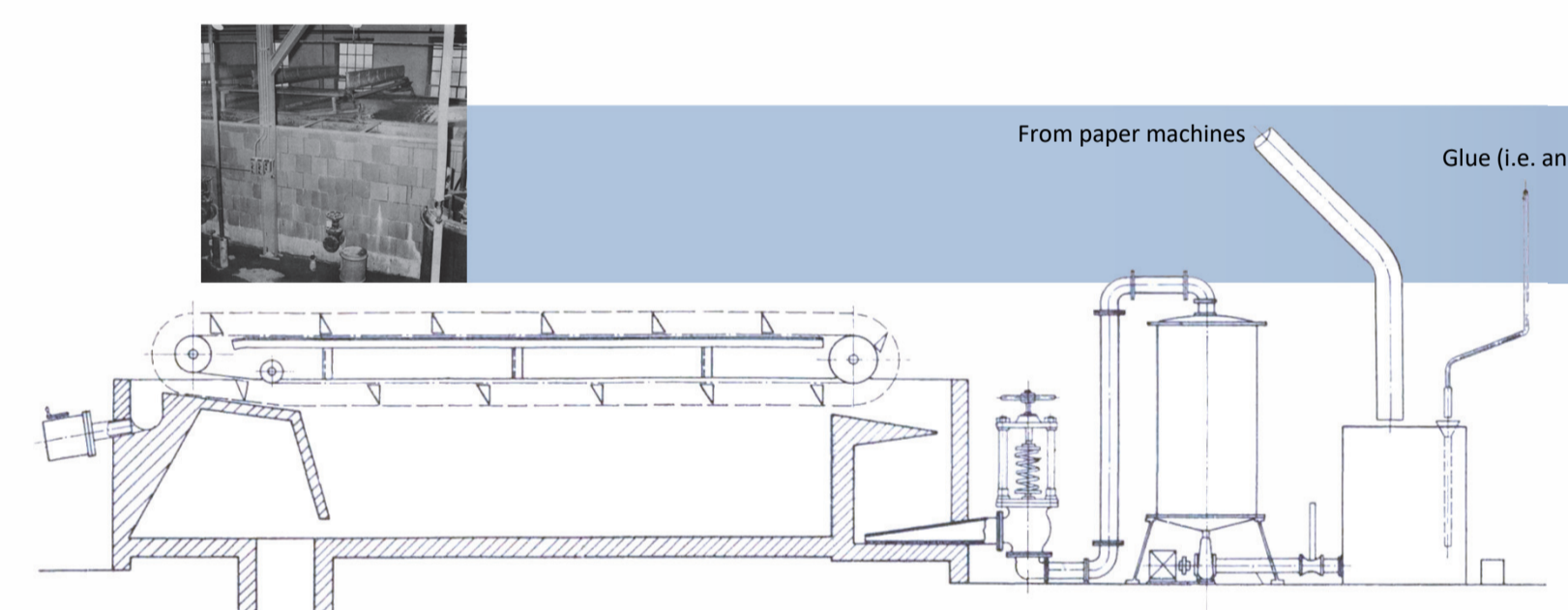
## Mechanically agitated flotation cells with sub-aeration

Air is injected and then dispersed by the agitator reducing the need for extreme agitation for air entrainment. Modern optimised cells based on this general principle are very common in the minerals industry to this day.



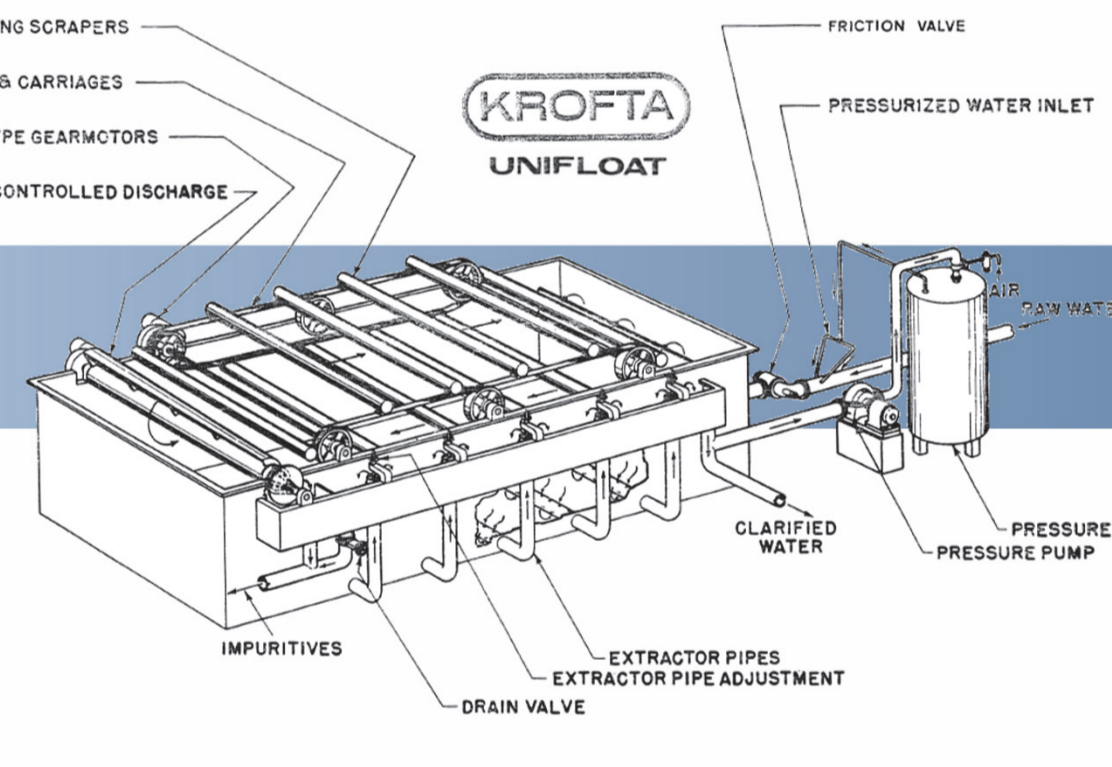
## Jameson Cell

Developed in Australia in the late 1980s, the Jameson cell creates bubbles for flotation in the downcomers as the feed is jetted in, entraining air and vigorously mixing it in. This technology has been very successful in the minerals industry, since it produces smaller bubbles than traditional sub-aerated mechanically agitated flotation cells (but bubbles are still likely bigger than achieved with dissolved gas flotation as used in the water and wine industries).



## Dissolved air flotation for paper wastewater

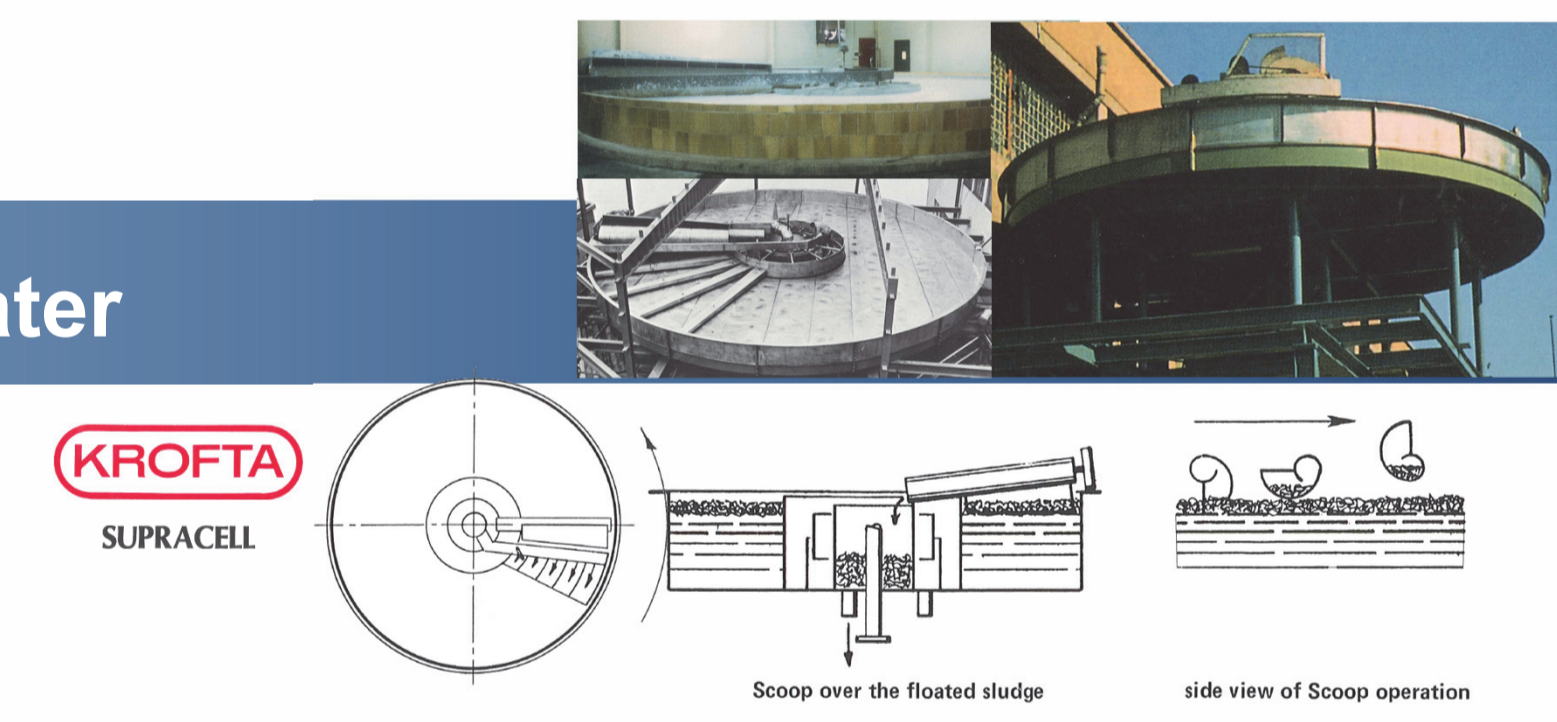
Dissolved air flotation was first used for water clarification in the Scandinavian paper industry in the 1920s. Air was dissolved under high pressure and released to generate fine bubbles. In the original Sveen-Pedersen process, Pedersen had designed the equipment, but it was only successful with Sveen's additives that enhanced flocculation of the particles and bubbles. Rectangular cells are convenient because they often fit in limited spaces.



## Partial recycle stream

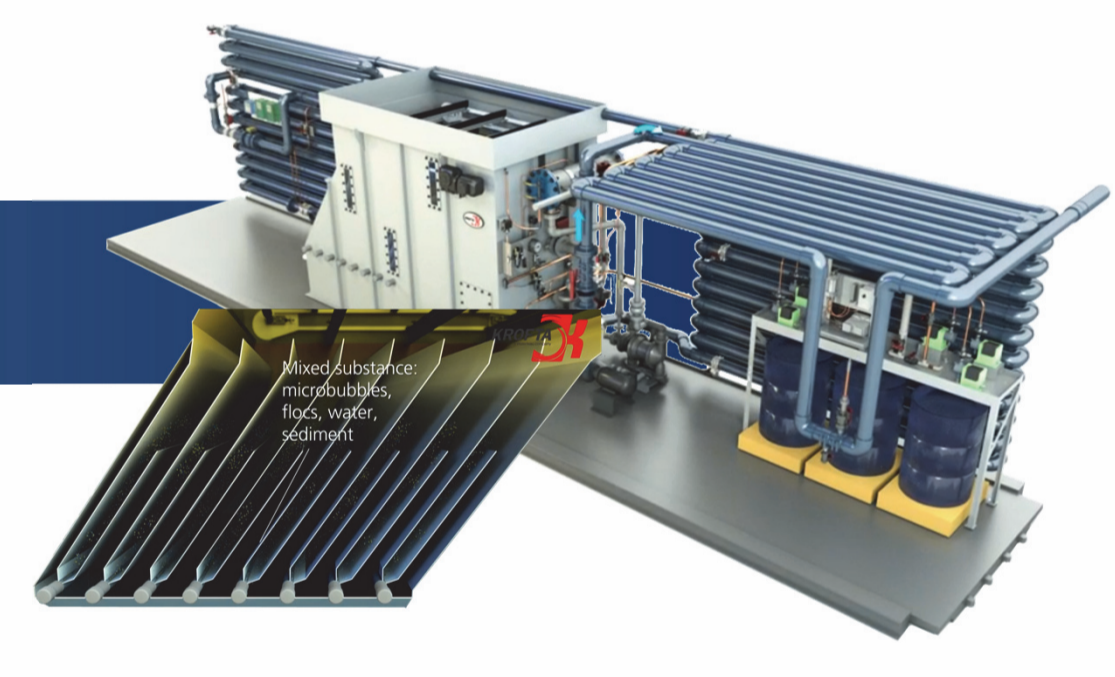
Instead of pressuring the entire feed to dissolve air, air is dissolved in a small fraction of the clarified water that is then mixed with the feed. This saves power, but may not be appropriate for feed streams with very high solids contents.

## Wastewater



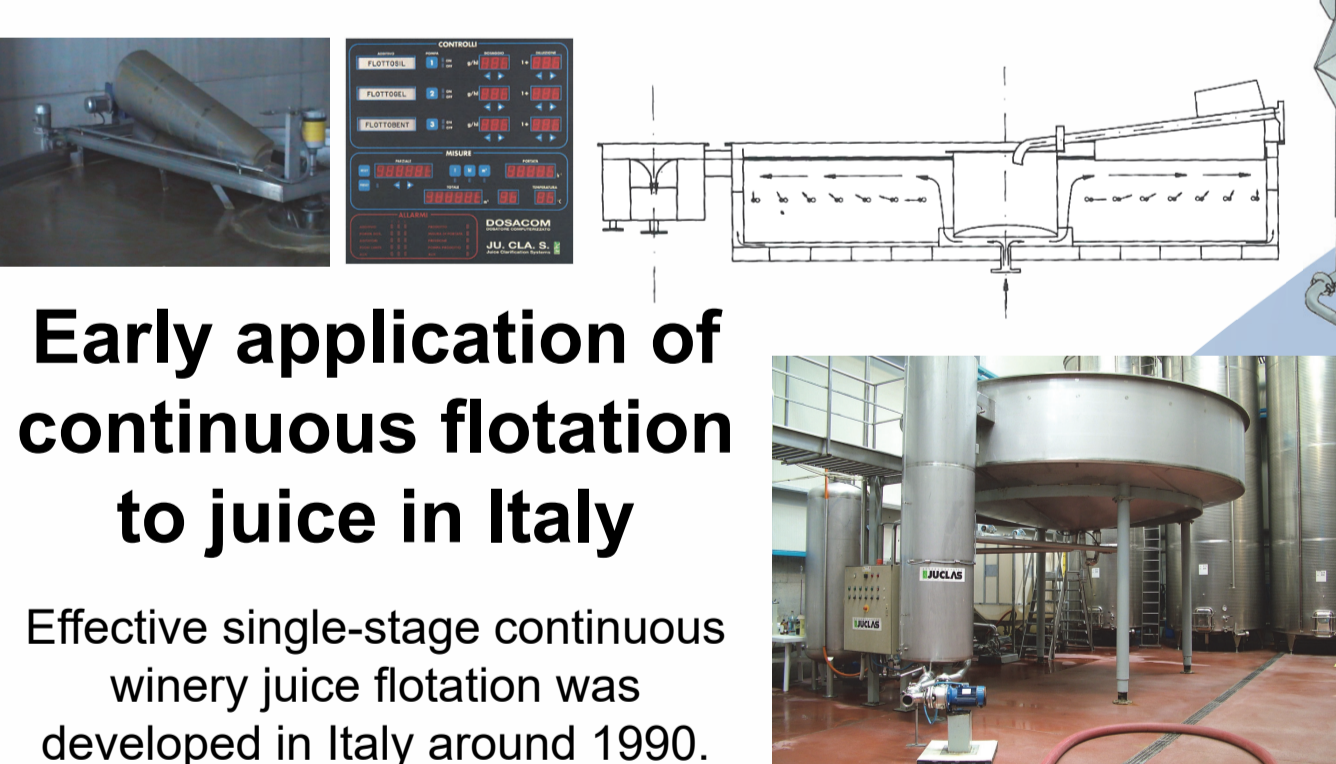
## High capacity shallow circular systems

Feed enters the separation tank via the arm in the opposite direction to its rotation such that the particle-bubble flocs are not disturbed. Floats are removed by a scoop on the same rotating arm (this process was introduced in the 1970s - other lower capacity circular systems had been used prior).



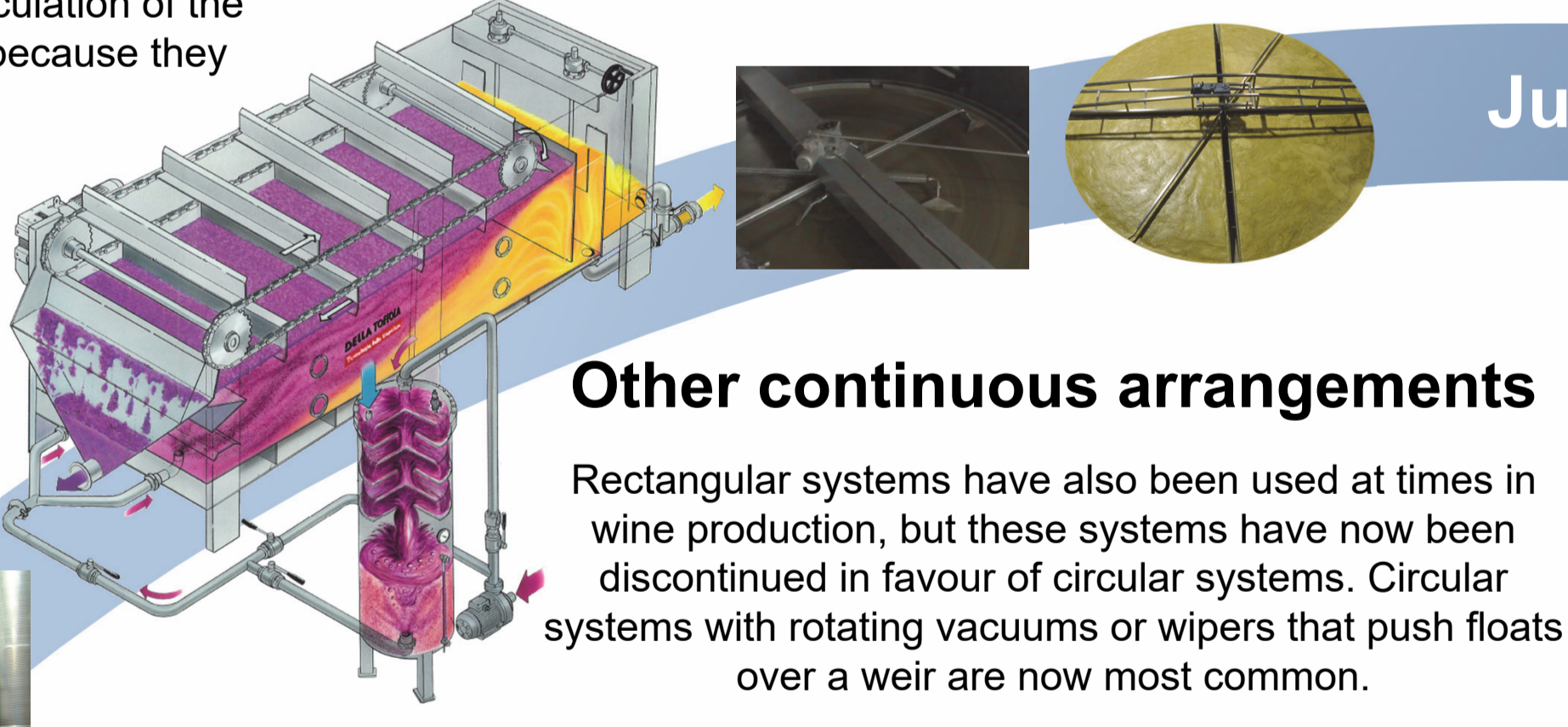
## High capacity rectangular systems

Even higher capacity per footprint rectangular systems use plate packs and are sometimes containerised for easy installation.



## Early application of continuous flotation to juice in Italy

Effective single-stage continuous winery juice flotation was developed in Italy around 1990.



## Other continuous arrangements

Rectangular systems have also been used at times in wine production, but these systems have now been discontinued in favour of circular systems. Circular systems with rotating vacuums or wipers that push floats over a weir are now most common.

## Juice

## Thermovinified juice

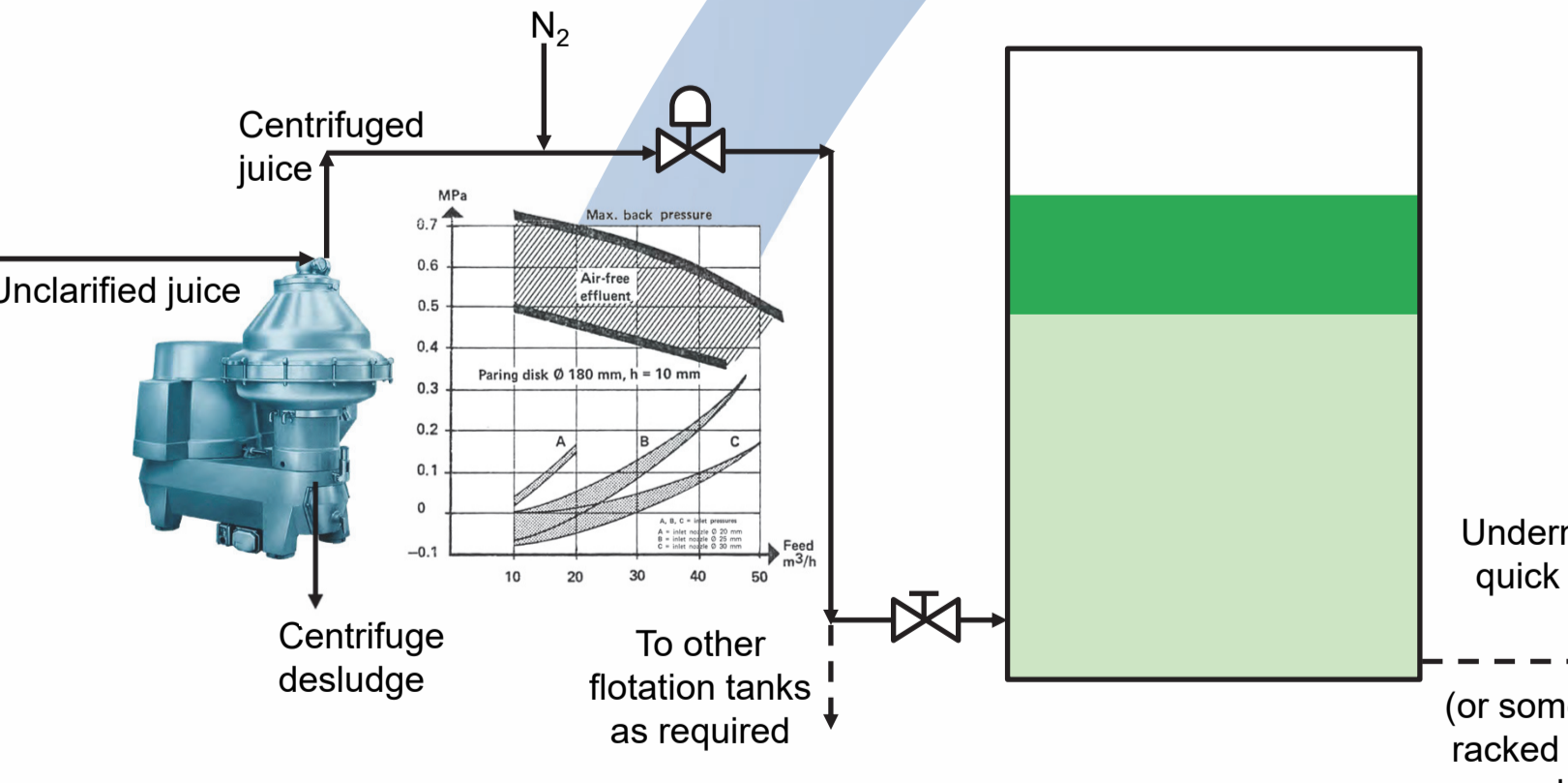
In addition to clarifying white juice, flotation is quite commonly used overseas to clarify red juice from heated/flash détente-treated grapes.

## Using existing winery tanks

This reduced the investment required for wineries to adopt flotation and allowed processing of smaller batches

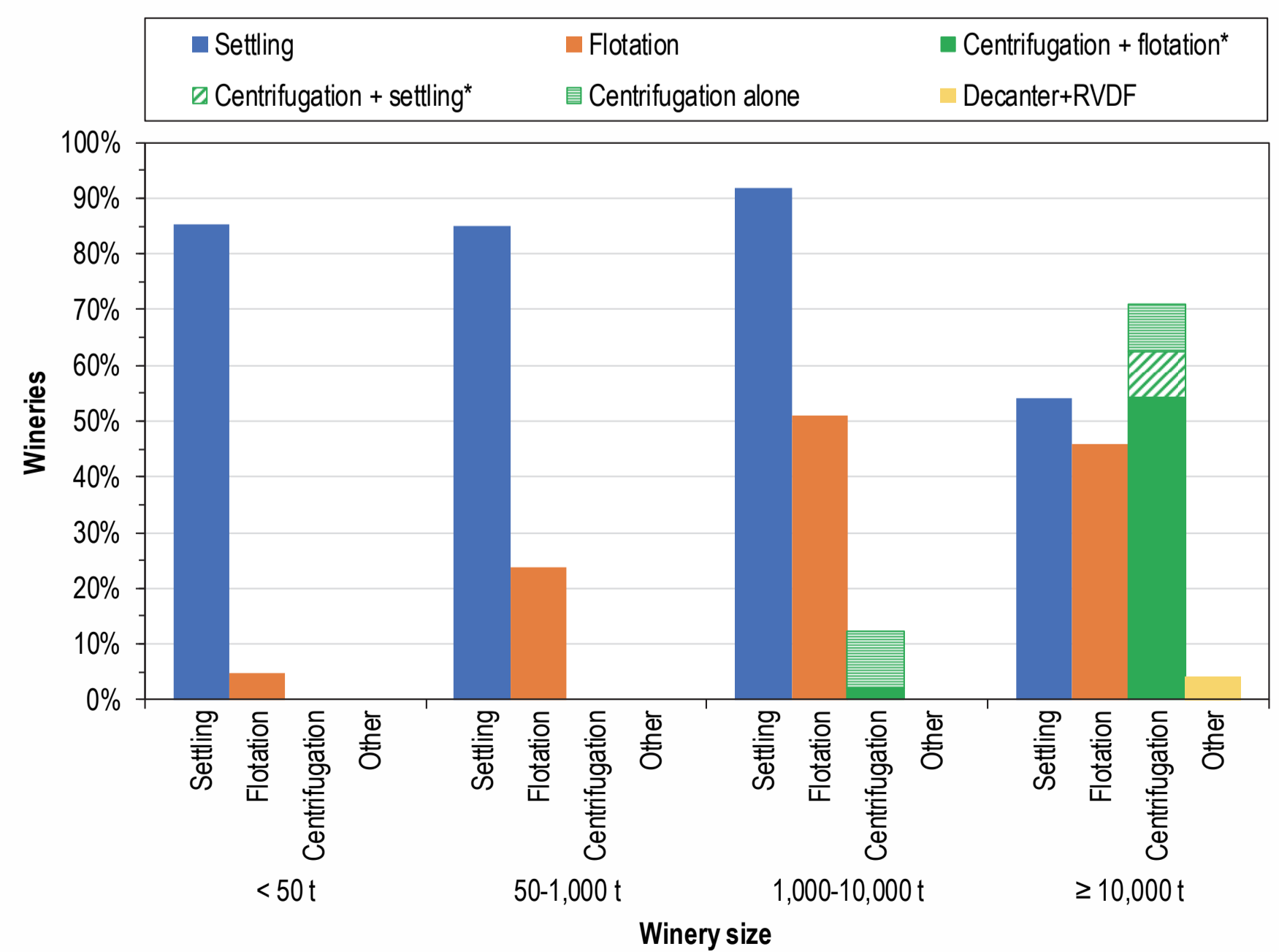
## Recirculating on a tank

This reduced investment even more by using much cheaper smaller gas dissolution systems, compensated by extra pumping (e.g. pumping tank over 1.5 times). This allowed processing of very small batches in a single tank, just like cold settling, bringing flotation within reach of all wineries, allowing them to reduce refrigeration requirements, achieve thicker lees and clarify juice more quickly.



## Centrifuge-flotation

An Australian invention - developed at Buronga Hill winery in the Murray-Darling. When centrifuges started to be used for juice clarification, it was found that air was being dissolved under pressure, and then released at the product tank, resulting in the flotation of residual particles (presumably the back-pressure was not sufficient to achieve the 'air-free' effluent shown on this centrifuge technical sheet). Systems were then refined to explicitly take advantage of this phenomenon. It allowed wineries to achieve much higher flow rates of juice through their centrifuges (prior to this some wineries used to settle following centrifugation to achieve acceptable centrifuge flow rates).



Wineries using different juice clarification techniques in Australia in 2016 ([www.awri.com.au/survey](http://www.awri.com.au/survey))

## Non-animal, non-allergenic fining agents

Pea and potato proteins, fungal chitosan, and bentonite are often now being used instead of gelatin to address consumer requirements for vegan and non-allergenic wines and to keep labels clean. Some of these agents and combinations work better than others.