Documenting 30 years of technological change in the Australian wine industry

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To mark the Wine & Viticulture Journal's 30th anniversary issue, we asked Peter to review the technologies used to make wine in Australia when the Journal was first published in 1986, using the articles published during its first three years in particular as a reference, and comment on their significance both then and now.

The last 30 years has been a period of unparalleled technological change in the Australian wine industry. This has been uniquely documented by the *Wine & Viticulture Journal* and its forerunners, *The Australian and New Zealand Wine Industry Journal* and *The Australian Wine Industry Journal*. The AWRI congratulates the publishers, editors and staff of the *Journal* on reaching the 30-year milestone, and on the resulting body of work that has been an essential reference source for generations of winemakers, viticulturists, marketers, students, suppliers and academics.

On a personal note, I have found the *Journal* to be an incredibly valuable resource during my career in the wine industry. The early volumes were a crucial part of my oenology and viticulture studies at Roseworthy, commencing in 1989, and later, as the manager of problem solving and extension services at the AWRI, *Journal* articles were a major component of the literature provided to industry as part of those services.

The past 30 years of extraordinary technological change have been captured in the *Journal*'s particular editorial and visual style, which is as recognisable in the first issue as it is in the current edition. The *Journal* has been as successful in capturing the cultural evolution of our industry as it has in charting the development of technology. An important aspect of this has been the breadth and depth of contributing authors and their readiness to share information for the benefit of the whole industry, with the editorial of the first issue noting "those who understand the industry ... will be able to write for their colleagues". The personalities, industry politics, success stories, controversies, booms and busts, are all documented; it has certainly been an eventful 30 years.


Rehydration and Propagation of Active Dry Wine Yeast

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The very first article in the first issue of the *Journal* discussed the use of dried wine yeast - a new technology for the time that is now taken for granted.

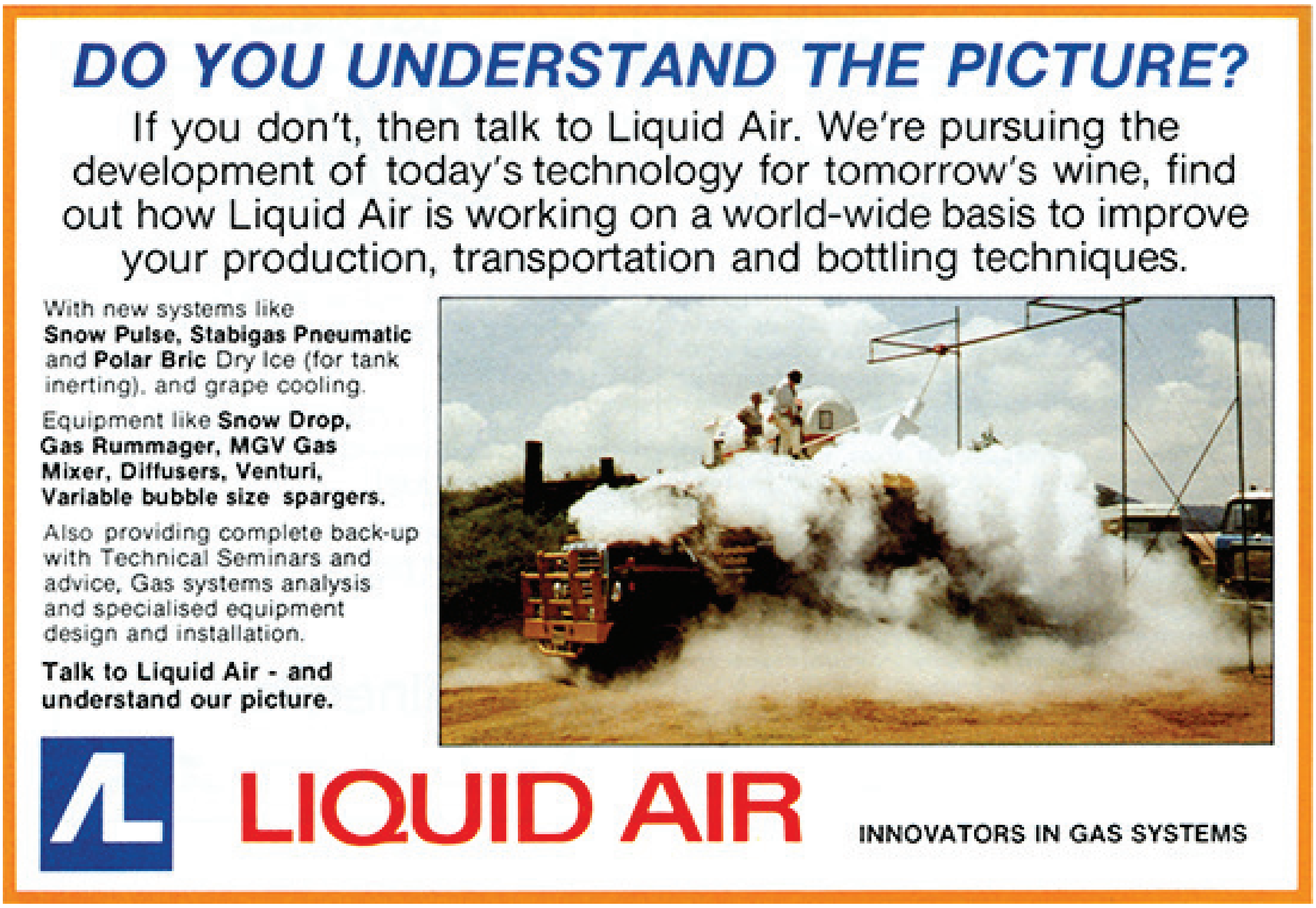
FROM 1986 TO 2016

A comprehensive review of the technological changes that have taken place over the last 30 years is beyond the scope of this article. Instead, this paper examines technologies being used to make Australian wine when the *Journal* was first published in 1986, mainly with reference to papers published in the first three years of the *Journal*'s life, in order to provide a snapshot of the time. Many technologies examined in early *Journal* articles now form the core of Australian winemaking, and have had an incalculable positive effect on wine quality and winemaking efficiency. However, in the mid-1980s, many of those technologies were either in their early stages of development, or perhaps more commonly, were merely very new to Australia. Therefore, while the early volumes of the *Journal* provide the impression that this was a period of rapid development of hardware and new processes, further investigation demonstrates that many of the technologies examined were already well established in other parts of the world. Nonetheless, it is clear that the *Journal* was an important vehicle by which information on those developments was communicated and spread through our industry, fostering the uptake of the technologies. This was surely a factor in igniting and supporting the industry boom that was to begin a few years later.

A large number of AWRI staff members, past and present, have made a prominent contribution to the *Journal* over its 30-year history, and the very first article in the first issue was authored by Paul Monk, who was then leader of the AWRI's microbiology group (Monk 1986a). As with so many of the papers that appeared during the first years of the *Journal*, the article discusses a new technology which is now absolutely taken for granted: the use of dried wine yeast. This was a very new technology in 1986, with the article noting that, "The acceptance of dried wine yeast has grown over the last three years." Thus, the use of yeast slopes, many of which were supplied by the AWRI, remained the dominant yeast propagation technology in 1986.

PROFILING TECHNOLOGIES AND PRACTICES

As well as documenting new technologies, the first issue contained the first of what were to become regular 'Technological Reports', titled 'Barrel fermentation – an ancient technique becomes modern technology' (Anon 1986a). With contributions from Geoff Schahinger (Schahinger coopers), Adam Wynn (Mountadam), Mark Turnbull (Saltram) and Chester Osborn (d'Arenberg), it is apparent from the article that widespread recognition and appreciation of barrel-fermented Chardonnay in particular was a relatively new phenomenon. While the first Australian Chardonnay wines fermented in small European oak had been made by Tyrrells in 1973 (French Oak), (Fowler pers. comm. 2016, Spinaze pers. comm. 2016), and Wynns Coonawarra in 1981 (German oak), (Hodder pers. comm. 2016), the 'Chardonnay boom' began in earnest in the mid-1980s. Notably, Sauvignon Blanc was the subject of the 'Varietal Report' in the first issue; at this time a 'new variety' to many, with the first and ground-breaking Cloudy Bay Sauvignon Blanc having been released a year earlier.



Then and Now: Liquid Air's advertisement from Issue 1 of the Wine Industry Journal in 1986 (Above) and today (right)

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Protease Enzymes for Protein Stabilisation

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Protein in wine is mainly derived from the grape where it forms during ripening. Like all other proteins it is made up of subunits of amino acids.

Unless certain fractions of grape protein are removed from white wine a haze can form. This may be due to the combination of protein with other wine components such as tannins, copper and iron, or to coagulation caused by exposure to elevated temperatures.

Red wines, and white wines in wood storage, often self-stabilise due to co-precipitation of tannin and protein. The introduction of early bottling of white wines and the development of inert storage containers has led to an increase in problems with protein haze formation in the bottle. Heat treatment and bentonite fining were introduced to ensure the removal of unstable protein before bottling.

Successful removal of protein by heat treatment requires elevation of juice or wine temperature to approximately 75°C for two minutes. Precipitation occurs and separation of the resultant particulate denatured protein can take place. This treatment has not become popular in Australia due to the energy costs, the capital required for effective plant and the modifications of juice and wine character caused by the process.

Bentonite is a colloidal clay containing negatively charged sites. Positively charged protein is adsorbed onto the surface of the bentonite particles, and co-precipitation can occur. Although bentonite is cheap and effective, its use does have several disadvantages. It is non-specific and can remove from wine any molecule with a net positive charge. The reduction of wine flavour compound concentration by bentonite treatment has long been suspected, and has recently been demonstrated in studies of aroma profile changes during wine processing.

Bentonite in the sodium form, as used in Australia, generates bulky lees. Large wineries usually recover wine from these lees but it is low in quality. Smaller wineries often discard the lees causing economic loss as well as pollution problems. Some wineries inject bentonite into the wine immediately before centrifugation. This can lead to excessive centrifuge bowl wear and a high volume loss through increased desludging requirements.

Recently, several alternatives to these conventional protein removal processes have been developed. These include protein adsorption onto synthetic alumino silicate or immobilised tannic acid, removal of protein by ultrafiltration, and the degradation of protein by protease enzymes.

Protease enzyme treatment

Protease enzymes have been used in other industries for many years. They can be derived from animal sources, e.g. rennet, used in cheese production, or from vegetable sources, e.g. papain, used to break down protein in beer. Protease enzymes can also be obtained as a by-product of fungal metabolism.

Protease enzymes work by breaking down protein into subunits of peptides and amino acids which have different properties to the parent proteins.

Many protease enzymes are not capable of breaking down protein in wine or grape juice, probably due to a lack of tolerance to low pH, ethanol, sulphur dioxide and other grape components. Recently, however, more tolerant enzymes termed acid fungal proteases, have become available. Work is being carried out with these enzymes in Germany and the USA. There is a growing awareness of the potential of these products in Australia.

The US and German studies have shown that the effective protease preparations are capable of reducing protein levels in grape juice by 50—70% after the addition of 50 ppm of enzyme and incubation for twelve hours at 46°C. This degree of degradation is also possible after the addition of 50 ppm of enzyme and incubation at 20°C, provided the juice has been flash heated to 90—100°C for 30 to 60 seconds prior to enzyme addition. This flash heating may break down bonding between protein complexes and other compounds, or uncoil globular protein, making the protein molecules more susceptible to enzyme degradation.

Results obtained in Australia also demonstrate that certain acid fungal protease preparations are capable of breaking down grape-derived, heat-unstable protein. Laboratory scale trials have shown that the enzymes are more effective in juice than in wine. Depending on the brand of enzyme, concentrations as low as 25 ppm are effective. Protein degradation occurs at temperatures as low as 8°C. Levels of free sulphur dioxide as high as 300 ppm do not appear to inhibit enzyme activity. Production scale trial results have verified some aspects of these laboratory experiments.

Testing for heat stability (80°C for 6 hours) has shown that bentonite fining rates are greatly reduced but that heat unstable protein breakdown is not complete. A varying amount of instability remains which is more dependent on the enzyme used than the dose rate or incubation time.

Advantages of enzyme treatment

The reduction in the bentonite requirement for heat stability can be as high as 90%. The use of proteases during production should reduce the volume of lees produced by bentonite fining, as well as minimising the risk of wine flavour loss or contamination.

The enzyme cost is $50 to $80 per kilogram. Use at a rate of 25 ppm will cost $1.25—$2.00 per 1000 litres. Offsetting this is the increased volume of quality wine, decreased lees recovery costs and a possible increase in wine quality.

Continued development of the enzymes and the way in which they are used should enhance the application of protease treatment to the wine industry. Further screening of

This article, from the second issue of the *Journal*, discussed the potential use of protease enzymes for the protein stabilisation of wines - written more than 20 years before the Aspergillopepsin 1 and 2 enzymes were demonstrated to be effective for protein stabilisation by the AWRI.

The Technological Report in the second issue of the *Journal* addressed stabilisation and clarification (Anon 1986b), a topic that has been periodically revisited over the life of the publication. This feature contained articles on several technologies that again were new to Australia at the time: the contact process for tartrate removal (Bott 1986), Silica Sol as a fining agent (Bearzatto 1986) and the use of carboxymethylcellulose (CMC) for the inhibition of tartrate crystallisation (O'Brien 1986). This was very new technology with important implications for winemaking worldwide, with the first systematic study having been reported in a German publication in 1984 (Wucherpfennig *et al.* 1984). Australian trials commenced in January 1985 (O'Brien 1985, O'Brien 1986), and as an indication of the grape varieties that were of importance for bulk wine production at the time, those trials were conducted on Muscat Gordo Blanco, Sultana and Shiraz. Another article in the second issue of particular interest was written by Richard Gibson, who was then the quality control manager for Penfolds Wines and an AWRI council member (Gibson 1986a). The article discusses the potential use of protease enzymes for the protein stabilisation of wines, and was written more than 20 years before the Aspergillopepsin 1 and 2 enzymes were demonstrated to be effective for protein stabilisation by the AWRI. The article speculates that 'flash heating' might be a necessary part of a protease-induced stabilisation process, "as it may … uncoil globular protein, making the protein more susceptible for enzyme degradation", which later proved to be the case.

Another notable but brief article in the second issue of the *Journal* concerns the formation of the AWRI's first online library database (Benjamin and Baldwin 1986). This was cutting-edge technology in its own right, being well before the availability of the internet, and even email in Australia for all but a small number of staff of some universities, as illustrated by a heading in the article 'What is a computerised database?' The database, which was established with the support of the Thomas Walter Hardy Memorial Bequest, was hosted on the CSIRO's AUSTRALIS public access network, and the search costs of $1 per minute of 'logged-on' time were estimated to be between $15 and $30 for an average search, a considerable sum in 1986. The article noted that the database would "eventually incorporate the holdings of the John Fornachon Memorial Library", which is now the case, including the first 30 years of the *Wine & Viticulture Journal*.

PACKAGING TRENDS

From the very first issue the *Journal* included articles on packaging, with advances in packaging technology charted over its 30-year history. Notably, however, the only article related to packaging technology, as opposed to packaging design, in the first year of the *Journal* concerned the introduction of the now ubiquitous pressure-sensitive labels, as an alternative to the 'wet glue' technology that was still predominant in 1986. Articles on closures did not appear in the early years of the *Journal*, and perusal of the advertising in early issues and in its sister publication *Australian Wine Industry Directory*, leaves no doubt that cork (including technical cork) was the dominant closure and the four-litre wine cask was an entrenched packaging option. However, while the initial introduction of screwcaps in the late 1970s had been abandoned by several leading companies by the mid-1980s, the 1986 edition of the *Australian Wine Industry Directory* does carry a full-page colour advertisement for screwcaps, which displays a number of leading brand names of the time. The first of what became many AWRI articles related to cork-related taints and other problems did not appear until the February 1989 edition (Amon *et al.* 1989), despite Lee *at al.* (1983) having discussed the formation of 2,4,6-TCA and subsequent tainting of wine in a review presented at the Fifth Australian Wine Industry Technical Conference, and a comprehensive review of "cork related problems" (Amon and Simpson 1986) having been published in the April 1986 issue of the *Australian Grapegrower & Winemaker* – which would become a sister publication to the *Journal* in the mid-2000s. That paper was referenced in a *Wine Industry Journal* article in the sixth edition in August 1987, which discussed taints in barrel-matured wine (Amon *et al.* 1987).

WINERY CRUSHERS, PRESSES AND FERMENTERS

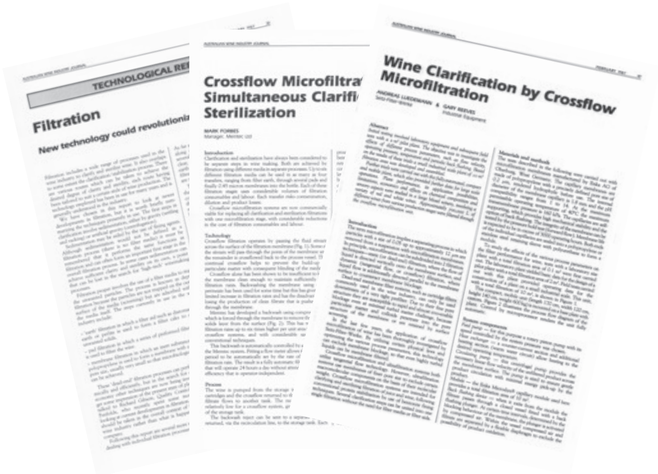
The subject of the Technological Report in the third issue of the *Journal* (November 1986) was another recurring theme over its history: Crushing and pressing (Anon 1986c). Much of the article is dedicated to descriptions of what are implicitly recently installed continuous-presses in large wineries, with Buronga Hill being described as "a newly established winery". The nature of the article suggests that membrane-press technology was a new concept for many Australian winemakers, despite the Willmes company having introduced the first horizontal rubber-bladder press in 1951, and the first air-pressurised membrane press in 1974 (Nordestgaard 2015). The August 1988 edition of the *Journal* noted, "The membrane press was developed by the German manufacturer Josef Willmes as a logical refinement to their airbag press" (Anon 1988b). The same issue included a report on the first Australian-made tank-press, being built by F. Miller and Company for the 1989 vintage (Anon 1988a). An associated article (Anon 1988b) suggests that the first Australian winemaker to install a membrane press was Brian Croser, who installed a Willmes TP4 at Petaluma in 1981. The article reports that Ralph Fowler had installed a Diemme rubber-bladder water press at Hungerford Hill in 1984, and states that Fowler considered the extra cost of air-pressurisation was not justified. The article then lists other winemakers who had installed air-bag presses as John Middleton at Mount Mary in 1986 and Nigel Catt and Andrew Garrett at Andrew Garrett wines, and also Andrew Mitchell of Mitchell Cellars in 1987. The article discusses the cost of membrane presses having been the limiting factor in their uptake to that point, but states that the increased yield of high quality juice being achieved by many producers meant the payback period was comparatively short, with Andrew Mitchell estimating that it was less than one year.

The November 1986 edition also contained other notable technical articles such as 'Quantifying the effect of pH and sulphur dioxide on young red wine colour' (Iland and Bruer 1986), and 'The Vinimatic Rotary Vessel: A new tool for the Australian winemaker' (Woodland 1986), which stated that these fermenters had already been installed in the Hunter Valley, Mudgee, the Murrumbidgee Irrigation Area, south-east Victoria, Coonawarra and McLaren Vale. However, as with membrane presses, the horizontal rotary red-fermenter was not a new concept, with Rankine (1986) stating, "The first rototanks (revolving horizontal red-wine fermenters) were installed at the Hermitage Hunter Valley winery in 1973", and the classic French text *Traité d'oenologie Sciences et Techniques du vin* published in 1977 including diagrams of various rotary-fermenters, including what would now be recognised as a 'Vinimatic' (Ribéreau-Gayon *et al.* 1977).

WINE MICROBIOLOGY

Several of the most in-depth technical papers in the first year of the *Journal* examined wine microbiology, and usually approached their subject from an avoidance of spoilage perspective; as was the case in the third issue, with reviews of 'hydrogen sulphide formation, utilisation and excretion' (Monk 1986b) and acetic acid bacteria (Drysdale and Fleet 1986). While these topics continue to be of relevance for each new generation of winemakers, the degree of spoilage caused by them is now undoubtedly far lower than in previous years, with the information provided by the *Journal* over three decades likely to have contributed substantially to winemaker education and the downward trends.

A similar stance is taken in the fourth issue, with a Research Report on yeast 'killer factors' (Heard and Fleet 1987), and an article on 'Yeast and bacteria' (Anon 1987a) which notes, "Selection of yeast strain is at this stage more important in avoiding poor quality than in enhancing wine. Points to consider are the avoidance of the production of nuisance compounds, such as hydrogen sulphide and acetic acid." The article contains only two short paragraphs in relation to bacteria; however, the following issue contained a four-page Technological Report on malolactic fermentation (Anon 1987b). That article refers to 'freeze dried' 'commercially available cultures' of malolactic bacteria, but was published seven years before the first direct-inoculation malolactic bacteria, Viniflora Oenos, was released in 1993, the USA patent for that preparation having been granted in December 1991. Beelman and Duke (1984) had described a method for producing freeze-dried cultures of malolactic bacteria, which was the basis of the techniques used to produce the freeze dried commercial cultures referred to in Anon (1987b). However, the 1991 patent application claims, "The reactivation of those strains takes at least 24 hours and up to several days and requires special facilities in the winery". It further claims,


TECHNOLOGICAL RE
Filtration
New technology could revolutioni
Crossflow Microfiltra
Simultaneous Clarifi
Sterilization
Wine Clarification by Crossflow Microfiltration

The fourth issue of the *Journal*, February 1987, contained a number of articles on the use of crossflow filtration for wine. The technology was revisited by the *Journal* three issues later, and again in the second issue of 1988. While the articles were all enthusiastic about the technology, its widespread uptake did not apparently occur for approximately another 20 years.

"(previous) attempts have been made to inoculate wine directly with lyophilized malolactic bacteria .... However, this resulted in quite a lengthy lag phase (where no malic acid was converted) .... and reactivation of the cultures was therefore recommended". While those assertions might be challenged by some of the producers or users of those early freeze-dried preparations, the availability of reliable direct-inoculation malolactic bacteria can be considered an important advancement on the methods being used in 1986.

WINE ANALYSIS

The technology of wine analysis has also developed greatly over the last 30 years, and the AWRI has been a leader in that development. The fourth issue of the *Journal* contains a short article (Anon 1987c) regarding the AWRI's purchase of its first automated analysis instrument, a SCALAR seven-channel segmented flow analyser. It was reported that as a result of this purchase, the cost of VI-1 analysis, which was required for export to much of Europe, had been reduced from $150 to $100. At that time, the AWRI's Analytical Service laboratory was possibly the only NATA-certified laboratory for VI-1 analysis, although Lindeman's' NATA certification was transferred from its Sydney laboratory to its newly completed Karadoc winery at about the same time (Goad pers. comm. 2016). The *Journal* article (Anon 1987c) noted that the SCALAR instrument included "a computer with an 80Mb hard disk for storage of data which will provide a database of analytical information concerning the composition of Australian wines". That database of results of analysis of commercial wines has been maintained and built on since the mid-1980s, and is periodically mined in order to produce information on the composition of Australian wines. The most recent publication (Godden *et al.* 2015) plots the evolution of Australia's wine offering between 1984 and 2014, neatly coinciding with the 30-year life of the *Wine & Viticulture Journal*.

FILTRATION

The fourth issue of the *Journal* (February 1987) is notable because the Technological Report contains a number of articles concerning the use of cross-flow filtration for wine (Anon 1987d, Forbes 1987, Luedemann and Reeves 1987). As with protease treatment for protein stability, Penfolds Wines QC manager and AWRI council member Richard Gibson was at the forefront of the investigation of this technology, stating in Anon (1987d) "the time has come where winemakers are looking closely at the total filtration process, which can run to D.E., two grades of pad, a membrane pre-filter and a final membrane. There is now available one technique which can replace all of these steps, especially for white wine production. It is crossflow microfiltration". The previous year, Gibson had also authored another paper on crossflow filtration in another publication (Gibson 1986b). Anon (1987d) notes, "Crossflow microfiltration systems have been commercially available for only 2-3 years, but with several wine companies having now successfully trialled systems, they are set to take off. If European experience is any guide, they could become standard equipment in about five years for white wine filtration". This technology was revisited by the *Journal* three issues later (Tarring 1987), and again by Richard Gibson in the second issue of 1988, where, in an article titled, 'Crossflow microfiltration – four years on', he reviews trials performed around the world (Gibson 1988). However, while all of these articles are enthusiastic about the technology, its widespread uptake did not apparently occur for approximately another 20 years.

CONCLUSIONS

To conclude, most of the technologies reviewed in this paper originate overseas, and it is their introduction and development in Australia which is charted by the *Journal*. However, the final technical article in the fourth edition of the *Journal*, which marked the conclusion of its first year, concerned a new piece of Australian winemaking technology that has seen near complete worldwide uptake: the silicone barrel bung (Anon 1987e). While the first line of the article states, "Some of the greatest inventions are also some of the most simple", the five-piece bung described in the article was later simplified to the single piece of silicone that is nearly ubiquitous in cellars worldwide today. While this invention was certainly simple compared with many of the other technologies discussed here, its advantages compared with what it replaced could be seen to symbolise the degree of change that has taken place in our industry over the life of the *Journal*. When the first edition of the *Wine & Viticulture Journal* was published, wooden shives were the norm for sealing barrels. These were circular, tapered pieces of wood that were hammered into the bung-hole, and made airtight with the aid of strips of hessian or calico, with the addition of 'bung putty'. We have certainly come a long way in 30 years.

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