4

WORLD FIRSTS

A hundred years ago the people of Australia dwelt in a golden age, constantly discovering how much they could achieve on their own initiative and resources. The colonial spell had been broken. They met challenges with imaginative answers of their own; challenges of the kind that their predecessors would once have needed overseas inspiration to face, usually mimicking British practice.

The assurance and self-reliance they were finding must have seemed then to be a permanent condition or one destined to strengthen with future generations. With hindsight we can see that it was just a window in history. Until the 1880s Australians were too few, too new and too innocent of their common identity to have developed such assurance and self-reliance. Later on, the global entanglements and loss of life of World War I, and the devastating influenza epidemic that followed, broke down the assurance. The notion that Australian civilisation would develop independently, the peer of European civilisation and American civilisation, faded. Presumably that notion would have revived, but the consecutive disasters of the Great Depression and World War II took its chance away. But ever since, whenever Australia is seen taking a positive part in the world, the legacy of that age of vitality, just before and after Federation, is manifest.

The Federal system was one of the most notable accomplishments. While statesmen here learnt from the examples of the United States and Canada, they worked our whole constitution out at private meetings and public conventions in the 1890s—resisting the temptation (almost all of the time) to pen a high-sounding manifesto, drafting instead a dry-reading blueprint which stably retains its efficacy through succeeding ages.

Our form of parliamentary government is known as the Westminster system, after the British Parliament. This obscures the extent of Australian innovation in modern government. In instituting parliaments democratically elected by secret ballot, the colonies were leaders and Britain was the follower. Victoria's first elections in 1856 were the first popular elections in the modern world by secret ballot. The first polling booths were designed for the occasion by Melbourne lawyer Henry Chapman (1803–81). Ballot papers with candidates' names printed beside boxes were invented, for South Australia's 1858 Legislative Council elections, by the returning officer W.R. Boothby (1829–1903).

Giving women the vote had been tried in parts of America (though they had to satisfy a property qualification) and universal female suffrage was pioneered in New Zealand's 1893 elections. South Australia went further in 1894, making its parliament the first in the world open to women members (although no female candidates stood).

There was argument in Britain, beginning in the 1850s, about whether that nation could properly learn from Australian constitutional innovations. On the subject of the secret ballot, for instance, *Chambers's Encyclopaedia* wrote:

> In the colonies of Sydney and Melbourne, the ballot is said to have worked well, though it has been doubted whether its efficacy has been properly tested in these countries, in which there is so much individual independence, peculiar to new countries, that those who vote care little for concealment.

However that may be, Britain adopted the South Australian style of secret ballot in 1872. Canada followed in 1874, Belgium in 1877, and American states one by one, starting in 1888.

Britain today has almost caught up with Australian practice; but it still has the primitive "first past the post" system, which awards each seat to the candidate with most votes, even if a minority. Australia's preferential system was adopted by Western Australia and Victoria in 1911, spreading thereafter to all mainland states and the Commonwealth.

In the self-reliant spirit of the Federation era, some people looked forward to "cutting the painter"—their nautical metaphor for severing allegiance to the British Crown. But most still took a certain pride in the Empire. Amongst them were those who promoted a new imperial model in accordance with Australian ambitions. Foremost was Billy Hughes (1862–1952)—Australian prime minister from 1915 to 1923. He proclaimed an Empire with the King of England at its head, and sovereignty distributed amongst a number of equal-ranking national governments, of which his Commonwealth Government in Australia was one and Britain's at Westminster another.

Consistent with this concept, he successfully insisted on a place for Australia at the Versailles peace conference in 1919, which demonstrated Australia's standing as an independent power. Most later leaders have been content or eager to defer to Britain or America on the international scene.

The very positive view Australians once had of their own society was matched by a negative attitude to other nationalities. Literature and journalism of a hundred years ago are full of snide assessments of non-Australians. British hauteur was ridiculed because it threatened the vision of a society in which the common man was entitled to be heard and rewarded without being subject to the dictates of privilege. In the nineteenth century, the same vision inspired condemnation of the Chinese, who worked for low wages and often as strikebreakers. The White Australia Policy was central to the Labor Party's platform until the 1960s, reflecting fears that cheap Asian labour would open the way to class exploitation.

Visiting the Child Accident Prevention Centre at Melbourne's Royal Children's Hospital in 1985, the Prince and Princess of Wales inspected the Safe-N-Sound baby capsule.

Many people admired the White Australia Policy as a local initiative for preserving the hard- won rights of common people. In global terms, the policy of multiculturalism that emerged in the 1970s is a far more distinct and original direction to have taken. Elsewhere in the world, ethnic nationalism dominated social and political organisation throughout the nineteenth and twentieth centuries. It swept away the surviving multicultural powers, such as the Hapsburg Empire, the Ottoman Empire and the Soviet Union. In taking a modest step in the opposite direction, Australia was truly innovative.

"The way John Bull looks at it. Great heavens! If you drop the Chinaman he'll smash my trade."

Alfred Fischer's cartoon in the Bulletin *(1888) summarises the anti-Chinese and anti-British thinking of some Australians, and the fears which produced the White Australia Policy.*

Australia's initiatives in government and social policy reflect the concerns and priorities of its people. The egalitarian spirit that promoted democratic elections and the White Australia Policy also made Australia the first modern country to implement a basic wage—a result of the High Court Harvester decision in 1907, which ruled on a dispute between Hugh McKay's Sunshine Harvester company (see page 13) and trade unions.

Exasperation felt by land owners prompted South Australia in 1858 to institute Torrens title. This system of land tenure had been devised by Adelaide parliamentarian Robert Richard Torrens (1814–84), who immigrated from Ireland in 1840. Torrens title was law throughout Australia by 1872. Most English-speaking countries followed suit over the next fifty years. Torrens title looks very good if you compare it with the cumbersome "old system" of English common law. However, more or equally straightforward systems have prevailed in non-English speaking countries for thousands of years.

The same reservation does not apply to legislation for compulsory use of car seatbelts, testament to Australian concern for life and limb. Victorian legislation of 1 January 1971 is thought to be the world's first and many countries now have similar laws. Legislation in the 1980s enforced the use of special capsules for transporting babies in cars, following the release in 1984 of "Safe-N-Sound" capsules designed in Melbourne. Throughout the twentieth century Australia's pre-occupation with preserving life and health prompted breakthroughs in medicine that the rest of the world has adopted.

MEDICAL RESEARCH

Before Federation, Australian medicine progressed more slowly than the new challenges it had to face. Eagerness to catch up is apparent in the foundation of research facilities that attracted community support throughout the twentieth century. Early examples include the Australian Institute of Tropical Medicine, founded in Townsville in 1909; and the Commonwealth Serum Laboratories and the Walter and Eliza Hall Institute of Medical Research—both founded in Melbourne in 1916.

You don't meet people like Eliza Hall (nee Rowden Kirk) (1847–1916) every day. Born in Melbourne, in 1874 she had married Walter Hall (1839–1911), an owner and manager of Cobb and Co. coach lines. Throughout her married life Eliza Hall worked for the underprivileged and in 1911 she went ahead with a plan to give her country a present—something to promote health, religion and education and to fight poverty. This took the form of a donation of £1,000,000—more than the whole annual taxation of most states. The institute named after Eliza and her husband has been the most fruitful of many outstanding medical research centres in this country.

A hot air cabinet developed by Anton Breinl at the Australian Institute of Tropical Medicine. In 1919, it enabled him to measure physiological responses to heat under controlled conditions—part of his research into the adaptability of white settlers to tropical climates.

The pathogen responsible for Q fever, which produced symptoms of pneumonia and fever, was identified at the Walter and Eliza Hall Institute in 1935 by Macfarlane Burnet (1899–1985). Burnet was director of the Institute from 1943 to 1965, and many discoveries justify his reputation as the world's foremost immunologist. Macfarlane Burnet was knighted, and in 1960 won the Nobel Prize for Medicine. Before its name was shortened, Q fever was labelled "query fever" because medical science was baffled as to a cause. *Coxiella burnetii*, the germ that causes it, is midway between a virus and a bacterium. It is one of many diseases now understood and controlled thanks to Australian work.

DISEASES

In 1901 a limited outbreak of bubonic plague in New South Wales enabled researchers Frank Tidswell and Ashburton Thompson to discover that plague is carried by a bacterium borne by the fleas that breed on infected rats. Their findings, in combination with parallel work being done overseas, helped civic authorities combat the conditions that allow bubonic plague to develop.

In Queensland, Thomas Bancroft discovered in 1902 how the hookworm parasite enters the body through the skin and, in 1905, that dengue fever is carried by a mosquito-borne pathogen.

In Victoria in 1949 gastroenterologist Charlotte Anderson worked out how to distinguish coeliac disease from cystic fibrosis. Three years later her team in England revealed the gluten-free diet that is the main element in treatment of the potentially lethal condition (see page 60).

In Sydney, observation by doctors of mothers of malformed babies led to many defects being linked to German measles (rubella) by Norman Gregg in 1939, and to the morning sickness drug Thalidomide by William McBride in 1961. Gregg's work led to development of rubella immunisation programmes for girls and McBride's findings put a swift stop to the use of Thalidomide all over the world. In 1951, Kate Campbell, a Melbourne paediatrician, discovered that blindness in premature babies was caused by overdoses of oxygen—leading to a condition known as retrolental fibroplasia.

Melbourne scientists investigating the cause of gastroenteritis discovered the rotavirus in 1973. Their success

followed the initiative of Ruth Townsend, of the Gastroenterology Research Unit of the Royal Children's Hospital, of having biopsies examined under the electron microscope, which was done by Ian Holmes at Melbourne University.

A controversy about disease treatments erupted in the 1930s when Sister Elizabeth Kenny (1880–1952) denounced the established methods of treating infantile paralysis (polio). Sister Kenny argued that polio symptoms are caused by spasm in those muscles that are not operating correctly and that the disease should be treated by stimulating such muscles. Born at Warialda in northern New South Wales, Kenny encountered polio victims in her work as a bush nurse in inland Queensland, and she outraged southern

> A PEOPLE OBSESSED WITH CARS

Motorcars had not been in production for long in Europe before people began building them in Australia. David Shearer of Mannum, South Australia, built a steam car in 1894. In Sydney Charles Highland's petrol car of the same date never travelled more than a few hundred metres and frequently burst into flame. His 1896 model was much better. No major manufacturing industry grew out of these and other early efforts, even though Australia was quick to become an important market for cars.

The full fledged car-making industry established after World War II is still one of Australia's most active arenas for industrial design. Many of the components are designed in Adelaide, Geelong, Melbourne and Sydney, by the major manufacturers and the component makers who supply them.

The strong visible differences that distinguished one make from another have faded out on new models since the 1970s, but one vehicle remains distinctly Australian in form: the utility, or "ute".

The idea for a ute came from a farmer who wrote to Ford Australia in Geelong, in 1933, asking if they could make a new sort of vehicle. "The front is the coupe, to suit my needs for taking the family to church on Sunday … The back is to be the roadster utility box so I can take my pigs to town on Monday." In those days factories like Ford's were just assembly shops, using mainly imported parts. But most bodies were made in Australia, so it was feasible to introduce a new type. Ford's chief body engineer, Lewis Bandt, designed the first ute in 1933, and this model was coming off the production lines by 1934.

Mechanically, Australian manufacturers are pretty conservative, but inventors here are always coming up with bold ideas.

Above: *Unlike some of our car technology the "buff catcher" is not a major export earner. Its ingenious bionic arm is ideal for capturing feral cattle on the run.*

Left: *The award-winning 2001 body design of the Holden Ute is the lineal descendent of Australian designs of the 1930s. Holden is a trade mark of General Motors, which released its first ute on the Australian market in 1934.*

Australians invented the best reflectors and intermittent wipers. At least three inventors have set up companies to build engines without conventional cranks; A.G.M. Michell's Crankless Engine Company (see page 80), Ralph Sarich's Orbital Engine Corporation (1972) and Rick Mayne's Split-Cycle Technologies (1988). Their combined practical effect on the industry is negligible compared with the worldwide impact of A.E. Bishop and Associates' power steering systems. Sydney engineer Arthur Bishop has been working on steering technology for decades, and his company has over 300 patents. The most impressive achievement is the variable ratio rack-and-pinion steering gear, which provides low-ratio power steering on sharp turns for superior control and manoeuvrability.

experts by drawing novel conclusions from her own observations. She established the first of several clinics in Queensland in 1933.

Remarkable cures were reported, but doctors protested at her method. In 1937 a royal commission heard evidence from many sources on polio treatment and the following year handed down a decision condemning her method. Elizabeth Kenny eventually went to America and promoted her treatment more successfully there.

PHARMACOLOGY

Most of the many drugs and vaccines developed by Australians are highly specialised. One exception is Aspro. For thousands of years pain has been managed with extracts of birch and willow bark, both containing salicylic acid. The concentrated and most effective form, Aspirin, was first produced in Germany in the 1890s and was still protected by German-owned patents when World War I broke out. In 1915, Melbourne chemist George Nicholas (1884–1960) took advantage of wartime suspension of enemy patents to make a product even purer than Aspirin. He registered Aspro as a trade mark in 1919 and founded the Nicholas pharmaceutical company.

The most revolutionary of all drugs is perhaps penicillin, extracted from cultures of penicillium mould at Oxford University by a team led by Adelaide scientist Howard Florey (1898–1968). The drug was first extracted in sufficiently stable form by an involved freeze-drying procedure in 1940. Florey did not patent the process, which he wanted to leave freely available. Instead he went to America and helped organise mass production for military use. In fact, though, if Florey and his team had obtained patents they could probably have advanced the availability of penicillin more effectively. They could have licensed all comers to unrestricted use or have licensed free use in exchange for sharing of production technology. As it was, American manufacturers were able to control world production by patenting the manufacturing processes. The patent system gives inventors a measure of control, which they can always use in an altruistic way if they wish, but their control is lost if they do not patent their invention at all.

Australian production began at the Commonwealth Serum Laboratories in 1943. Few Australians have had the recognition that Florey's discovery earned him. He was knighted in 1944, shared a Nobel Prize in 1945, became president of the Royal Society in 1960 and a life peer, Baron Florey of Adelaide and Marston, in 1965.

In 1949, at Melbourne's Royal Park Psychiatric Hospital, John Cade (1912–1980) was the first to discover the effectiveness of lithium, a metallic element, in treating psychiatric conditions.

The pregnancy hormone relaxin helps prevent premature labour and difficulties in delivery that can injure the newborn baby. After years of research beginning in 1975, scientists at the Howard Florey Institute of Experimental Physiology and Medicine in Melbourne worked out how to produce relaxin artificially with genetic engineering techniques. They patented their process in 1983.

In 1981, the Commonwealth Serum Laboratories (CSL) released a funnel web spider antivenene, the most effective counter ever to the deadliest of spiders. Developed over twenty-two years by Struan Sutherland, it was a major breakthrough, and one of a long series of vaccines and antivenenes developed by CSL (see page 63).

> A LETHAL DISEASE MEETS ITS MATCH

"You'd best stay home and help your mother," said Charlotte Anderson's father when she finished school during the Depression. But Mother was going to have to make do unaided: Charlotte won a government scholarship and, in 1936, graduated from university a Master of Science. She was then employed for several years as a research biochemist but went back to her studies to take a degree in Medicine, graduating in 1945. After a term as resident at Royal Melbourne Hospital, she became the inaugural registrar of the Clinical Research Unit, set up at the Royal Children's Hospital by Dr Howard Williams in 1948. She began working on tests to distinguish between coeliac disease and cystic fibrosis—two diseases that prevent absorption of nutrients in the small intestine, with identical, often lethal, symptoms, but which require different management. By 1949 she had a test that was reliable enough for hospital use. In 1950 she went to England to deepen her study of nutrient absorption problems at London's Great Ormond Street Hospital for Sick Children. Two years later she attracted international publicity as a member of the research team, based in Birmingham, which found that coeliac disease can be controlled by a gluten-free diet.

Her vital achievements in Melbourne in the 1950s and 60s include establishing her gluten-free diet as standard treatment for patients with coeliac disease, who can now lead almost normal lives as a result. She campaigned successfully to get Australian manufacturers to produce gluten-free foodstuffs—a breakthrough on her part and theirs, because even in many products that seemingly contain no wheat, it is simplest for manufacturers to include traces of gluten. When she began her work, cystic fibrosis—an inherited condition afflicting one newborn baby in every two or three thousand—was effectively an early death sentence for some patients. Because of the work of Charlotte Anderson and several others, it is normal now for patients to survive to adulthood.

Charlotte Anderson taking delivery of a new inhalation pump at the Royal Children's Hospital, Melbourne, in 1959. Pumps were already used in America to control chest infections in cystic fibrosis patients, but the new pump was produced in Australia by Repco, working to Dr Anderson's requirements.

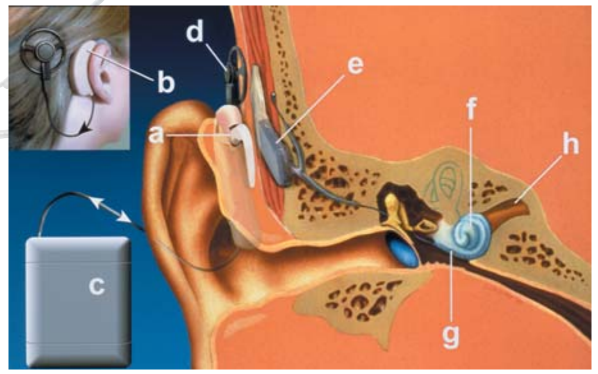
Surgical scalpels with retractable safety guards. This invention of Occupational and Medical Innovations Ltd is a dramatic twenty-first century illustration of how simple mechanical innovations can have major practical and economic benefits.

TECHNOLOGIES FOR PREVENTION AND CURE

The gift Australians have for putting together contraptions and practical methods has sometimes been traced to life on the land. When challenges arise on the spot, they are frequently met with improvisations in wire and bits of wood or a bold departure from the instruction manual. If it's true that inventiveness is the legacy of bush improvisation, then medicine has not missed out, as plenty of ingenious technologies demonstrate.

In 1926 at Sydney's Crown Street Women's Hospital, Dr Mark Lidwill had a newborn baby patient about to die from heart failure. He connected the child's heart to electrodes and saved its life by stimulating the heartbeat with electric pulses—thus creating the first heart pacemaker. Unlike most medical pioneers today, Lidwill was troubled with ethical concerns about prolonging life unnaturally. He never patented the pacemaker, and avoided recognition.

In the 1960s Dr Evelyn Billings and her husband John worked out a natural contraception procedure which came to be known as the "Billings method". They provided



Above: *The Cochlear implant: (a) microphone; (b) behind the ear speech processor; (c) body worn speech processor; (d) transmitting aerial; (e) receiver stimulator; (f) electrode bundle; (g) inner ear (cochlear); (h) auditory nerve.* **Top:** *manufactured components ready for installation.*

> THE QUEST FOR A SNAKE BITE ANTIDOTE

People who crank Australia up as “God’s own country” overlook its teeming venomous snake population. In His chosen land the Almighty would never have countenanced the slithering plethora of hideous snakes that we have to put up with. Naturally, when the settlers brought European medicines a snakebite antidote was one of its most urgent challenges.

The poet Banjo Paterson, in “Johnson’s Antidote” (1899), tells the story of one determined research project, which will do us for an indication of how effective nineteenth-century efforts were on this problem. The pioneering researcher William Johnson had the idea of drawing on Aboriginal lore. Johnson went on to observe the behaviour of local fauna:

Till King Billy, of the Mooki, chieftain of the flour-bag head,
Told him, “Spos’n snake bite pfeller, pfeller mostly drop down dead;
Spos’n snake bite old goanna, then you watch a while you see
Old goanna cure himself with eating little pfeller tree”[…]
Loafing once beside the river, while he thought his heart would break,
There he saw a big goanna fight with a tiger-snake.
In and out they rolled and wriggled, bit each other, heart and soul
Till the valiant old goanna swallowed his opponent whole.
Breathless, Johnson sat and watched him, saw him struggle up the bank,
Saw him nibbling at the branches of some bushes, green and rank;
Saw him, happy and contented, lick his lips, as off he crept,
While the bulging of his stomach showed where his opponent slept.
Then a cheer of exultation burst aloud from Johnson’s throat;
“Luck at last”, said he, “I’ve struck it! ’tis the famous antidote”.

Finally, Johnson submitted his antivenene to controlled scientific testing:

Then he rushed to the museum, found a scientific man—
“Trot me out a deadly serpent, just the deadliest you can;
I intend to let him bite me, all the risk I will endure,
Just to prove the sterling value of my wondrous snakebite cure.
Even though an adder bit me back to life again I’d float;
Snakes are out of date, I tell you since I’ve found the antidote.”
Said the scientific person, “If you really want to die,
Go ahead—but, if you’re doubtful, let your sheep-dog have a try
Get a pair of dogs and try it, let the snake give both a nip;
Give your dog the snakebite mixture, let the other fellow rip;
If he dies and yours survives him then it proves the thing is good.
Will you fetch your dog and try it?” Johnson rather thought he would.
So he went and fetched his canine, hauled him forward by the throat.
“Stump, old man,” says he, “we’ll show them we’ve the genwine antidote.”
Both the dogs were duly loaded with the poison-gland’s contents;
Johnson gave his dog the mixture, then sat down to wait events.
“Mark,” he said, “in twenty minutes Stump’ll be a-rushing round,
While the other wretched creature lies a corpse upon the ground.”
But, alas for William Johnson! ere they’d watched a half hour’s spell
Stumpy was as dead as mutton, t’other dog was live and well.
And the scientific person hurried off with utmost speed,
Tested Johnson’s drug and found it was a deadly poison weed;
Half a tumbler killed an emu, half a spoonful killed a goat—
All the snakes on earth were harmless to that awful antidote.

—“Johnson’s Antidote”, 1899

Ethnologists such as Baldwin Spencer, who studied Aboriginal medicine, did not discover a snakebite antidote. Rather, they found poultices, and perhaps most effectively, vapour baths being used as snakebite treatments, with limited success.

More promising work than Johnson’s began in the 1920s at Melbourne’s Walter and Eliza Hall Institute of Medical Research, when Neil Hamilton Fairly and his colleagues made intensive studies of toxins in snake venom. Tiger snakes were the most common of the lethal biters. In 1930 the Institute collaborated in the release of a superior tiger snake antivenene produced in Melbourne’s Commonwealth Serum Laboratories.

Before that the best treatment was Frank Tidswell’s (1867–1941) antivenene collected from horses that had been gradually immunised by increasing doses of tiger snake venom. In the 1950s, the Commonwealth Serum Laboratories released antivenenes for several snakes including the taipan.

The chief remaining problem was the fault of snakebite victims themselves, who are notoriously weak in powers of observation and presence of mind. They are frequently unable to identify the type of snake that bit them or even to describe it. Until 1968 the only solution was to dose them with every known antidote that might help. This could make them sicker than some snakebites would. But the Commonwealth Serum Laboratories then released an antivenene which is effective against the venom of practically all the deadliest Australian snakes.

In 1991 they went better still, with the Snake Venom Detection Kit. It features glass tubes lined with chemicals that react to venom samples from snakes found around the world. The kit identifies the venoms of different snakes by colour change, such as yellow for tiger snake and green for adders. With this aid a specific antivenene (which is better than the general one) can be used even on patients who have no idea what bit them.

Research into indigenous Australian drug lore has yielded benefits to modern pharmacy. The pituri plant (above), like Johnson’s antidote, could be used to poison emus. But in 1876 W.O. Hodgkinson learnt from Queensland Aborigines that pituri plants in one area can be taken by humans as a narcotic. The related species Duboisia leichardtii *supplies the active ingredient for Buscopan (opposite), which relaxes the muscles of the digestive system.*

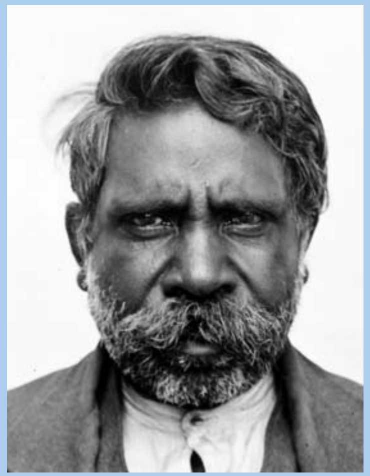
ResMed has made CPAP a practical reality for many patients since 1989. In earlier years, setting up continuous positive airway pressure was a major process for hospitals, as this apparatus, developed for the Royal Children’s Hospital in 1972 by John Stocks, demonstrates.

instructions for women to make a daily temperature test of the vagina to ascertain their fertility from one day to the next. This method soon became internationally popular, especially amongst single women, because it enabled women to avoid pregnancy with brief bouts of celibacy.

The Cochlear Implant, or bionic ear, is a surgically inserted aid which offers hearing to patients who are too impaired to benefit from old amplifier-style aids. Its tiny microphone refers sounds to a processor that can be worn or kept in a pocket. The processor splits the sound into multiple channels which communicate electric signals to the inner ear. The system is based on research done throughout the 1970s by Melbourne University’s departments of Otolaryngology and Electrical Engineering, led by Professor Graeme Clark. Taking advantage of the resulting patents, and Australia’s technological advantage, the Cochlear company under the leadership of Paul Trainor produced a commercial model, which it now supplies worldwide, supported by a network of its own clinics.

A similar success story begins in 1981 with pioneering work done at the University of Sydney by Colin Sullivan. Professor Sullivan was researching breathing disorders during sleep. In particular, he sought ways to diagnose and treat sleep apnoea—an under-recognised medical problem afflicting almost as many sufferers in developed countries as

> THE PERPETUAL IDEAS MAN



Not surprisingly the most original thinkers have often been keen amateur inventors—their fertile minds always thinking up new ways of doing things and new things to do. Some of their inventions embody flaws, which an expert can easily see will cause them to fail. At other times—being unconstrained by conventional teaching—they come up with striking breakthroughs. For instance, we would not have had aeroplanes, nearly so soon, if the world had relied on properly qualified scientists rather than gifted amateurs—who couldn't, or wouldn't, understand that their dream of manned flight was unrealistic with the resources available.

Australia has had quite a few inventors of this kind. A distinguished example is David Unaipon, an indigenous Australian born in 1872 at Raukkan Mission near Tailem Bend, on the River Murray east of Adelaide. His face appears on the $50 note, along with some of the drawings accompanying his patent applications.

David Unaipon attended the Mission school until 1885 when he went to Adelaide with a local family and developed his natural interests in philosophy, literature, science and music. As an eighteen year old, Unaipon returned to Raukkan Mission and continued his reading of scientific works and literature. He studied mechanics particularly intently and made his own experiments in mechanical and ballistic propulsion and polarised light. He also worked as a bootmaker and as the Mission's organist.

In his long life David Unaipon worked out dozens of inventions. In some things he was ahead of his time, and most of his inventions were never built to full scale. These reasons, as well as his unique genius, got him the nickname "Australia's Leonardo".

He lodged patent applications for at least ten of his inventions, one being an ingenious improved shearing handpiece, patented in 1909; another, a centrifugal engine, the fruit of his interest in propulsion (which included a study of perpetual motion). David Unaipon did not pursue any specialist studies at tertiary level, and it's doubtful that he would have had the opportunity to do so. In fact, though, he really believed that following up his basic schooling with a wide range of philosophic and scientific reading was a good way to cultivate his mind.

He acknowledged the value of education at Raukkan, but was only too well aware that it was not preserving indigenous lore, which was being lost as his people turned to a new way of life. He devoted much of his life to gathering and conserving Aboriginal culture. "As a full-blooded member of my race, I think I may claim to be the first—but I hope not the last—to produce an enduring record of our customs, beliefs and imaginings."

From 1913 he was employed to collect subscriptions for the Aborigines' Friends Association—an assignment which gave him the opportunity to travel large distances throughout South Australia and Victoria, gathering information as he went. He compiled a corpus of legends, which the Association began publishing in 1927. He also wrote poetry and an autobiography, *My Life Story* (1951). He delivered many lectures on Aboriginal customs and mythology, gaining a platform from which to comment on the social conditions of Aboriginal people and argue for equal rights. He acted as a spokesman for his people and an adviser to government on Aboriginal policy.

At Raukkan, late in life, he returned to the challenge of perpetual motion. Like the search for a way to turn base metals to gold and the dream of manned flight in earlier times, perpetual motion remains a fond goal for amateur inventors. Experts customarily ridicule their pursuit as a scientific impossibility. Isaac Newton's principle of the conservation of energy—"energy can neither be created nor destroyed"—means that a machine using energy in its operations must draw more energy to keep going. This is because some energy will always be lost as it works, in forms that the machine cannot reassimilate—particularly through friction.

David Unaipon was aware of this objection but believed he was getting close to discovering a way around it. He died in 1967, aged ninety four, without having accomplished his mission. But, as he was not the first, he was certainly not the last to attempt it and perhaps his successors will try to build on his work.

asthma, which is much more often diagnosed. Previous treatments had been either highly invasive or relatively ineffectual, so his nasal "CPAP"—continuous positive airway pressure—represented a great breakthrough. Making and commercialising the new system was a long process, which led to many related innovations. In 1989 the ResMed company was established to develop and exploit the advanced Australian technology for helping people with sleep apnoea and other respiratory problems.

ResMed now makes and markets a comprehensive range of diagnostic and therapeutic products for such disorders, including breathing aids and monitors, nose masks, headgear and tubing. Its products are the most advanced available. It is a truly multinational company, with offices in ten countries, and no less than 500 patents issued or pending. Most of ResMed's research, development and manufacturing is still carried out in Sydney.

DIAGNOSTIC SYSTEMS

The world's greatest dependence on newfangled Australian gadgets and systems is in diagnosis. Ultrasound technology, which uses sound waves to produce images of internal tissue, was made possible by research begun in the 1950s at what became the Ultrasonics Institute of the Commonwealth Department of Health, in Sydney. A scanner built there by George Kossoff and David Robinson in 1961 opened the way for the first practical system that could be installed in multiple locations. Ausonics, the firm set up to develop such a model, began manufacturing in 1975 and in 1976 released the Octoson scanner for breast imaging. A variety of other models maintains Ausonics' world leadership in ultrasound.

In 1985 Bill Burch of the Australian National University, together with researcher Ian Tetly, began producing "technegas", a fine cloud of synthetic carbon molecules that distributes a radioactive isotope over the interior of the lungs to enable diagnosis of pulmonary embolism.

In Melbourne two years later, the Murdoch Institute of Research into Birth Defects launched POSSUM—"pictures of standard syndromes and undiagnosed malformations". It was a set of laser disc images and data for over 1,500 syndromes, which was immediately popular in many countries. Agnes Bankier has been responsible for collating the data and demonstrating the system at home and overseas. By 1998, POSSUM covered 2,500 syndromes and had been written in the computer language Java for ease of distribution to over 500 hospitals in 50 countries via the Internet and on CD ROM. It enables doctors everywhere to take advantage of the latest statistics and wisdom on prognosis and treatment of conditions that may be rare and baffling. Similar packages are being developed at the Institute for other medical areas.

A Sydney company, Polartechnics, is making great strides in diagnostic technology independently of major research institutes. It specialises in appliances to diagnose complex conditions, such as cervical cancer, which are extremely easy to set up and use, and highly sensitive, so as to facilitate recognition of danger very early, even by unskilled operators. In 2002 Polartechnics began releasing a range of portable appliances including machines to detect cervical cancer and skin cancer, and a digital medical imaging system. These are far in advance of alternative technologies from overseas, such as the pap smear (see page 66).

IMPROVING ON LIFE

Australian scientists have not attempted to clone people—at least as far as we know—but they have certainly been active in the often controversial areas of biotechnology—and produced dramatic results.

Amongst the best known are Monash University's in vitro fertilisation and donor embryo programmes. The world's first human pregnancy by in vitro fertilisation was achieved at Monash University Medical Centre in 1973, but

Agnes Bankier with the original POSSUM. More recently it has been made available on standard CDs.

> OVERCONFIDENCE TRIUMPHANT

Cervical cancer is one of the most common cancers amongst women in developed countries, including Australia. In Third World countries the incidence is at least as high and cervical cancer is a potent killer. Screening by pap smear is an imperfect safeguard and often gives too little warning.

In 1987 two Australian professors raised 1.5 million dollars and established Polartechnics, a company dedicated to discovering better screening methods. Malcolm Coppleson might have become a test cricketer; that was before he left the game to concentrate on medical studies. Now he's one of the world's leading gynaecologists. Bevan Reid was not so good at cricket but was an outstanding oncologist, specialising in research into the pre-cancer stage.

Their research task was too big and they were counting on a lucky break or flash of inspiration. Polartechnics' money ran out before anything like that came, and in 1989, to see if there was any way for it to survive, the firm put a corporate executive in control of its business.

But Victor Skladnev—born in Germany to Russian migrants bound for Queensland—had been a scientist and mathematician before climbing the managerial ladder. It turned out he was driven more by wide-eyed enthusiasm than business acumen. He thought he could readily apply rigorous mathematical analysis to the indicators observed by Reid and Coppleson in cervical tissue.

Working in his garage morning and night without pay, Skladnev despaired as one analytical model after another produced muddled results. Then came what he calls his "eureka phase". He refined the model to recognise that all women differ. Tissue characteristics that had previously signified nothing suddenly became reliable indicators—when matched with age and a range of individual parameters.

Victor Skladnev attributes the breakthrough to the naivety behind all of Polartechnics' original ambitions. "I couldn't have got anywhere without misguided boyish optimism. That's how private ventures can achieve things which are too difficult for major institutions. I simply didn't know that what I thought we could do was unrealistic. So I kept going. I was thinking success was much closer than it actually was."

A scientist at work in one of Polartechnics' laboratories. In the mid-90s, close on 70 scientists were working full time on refining Polartechnics' technology.

At that point the main innovative work was complete but the hardest challenges lay ahead. Coppleson and Reid added money of their own, and on a shoestring budget Polartechnics battled to gain recognition and organise practical application for their discovery. They were simply not taken seriously and couldn't even get their findings published in a reputable journal.

So Skladnev built a handmade prototype screening mechanism. Protected by patents and with a device that proved the superiority of their method, they were ready to seek the investment to perfect, manufacture and distribute their revolutionary technology. They had all heard the stories of inventors who scoured Australia looking for development capital, only to wind up having to take their ideas to livelier investors in other countries. So they went overseas immediately, and made a striking impression, especially in Japan, where cervical cancer is the second most common cancer in women.

Alas, one by one all the assurances they'd received fell through, and in 1992 they despondently regrouped in Sydney. Malcolm Coppleson decided to speak to Tony Grey, a Canadian with a "can do" philosophy of business, who had moved to Australia in 1972 and built a very successful mining enterprise. In a reversal of the proverbial trend, they found their capital in Australia, having scoured the world unsuccessfully. Investors recruited by Tony Grey—who became the company's executive chairman—came forward with tens of millions of dollars, which they knew would take years to recover.

Now Polartechnics has patents and registered trade marks for three revolutionary devices. "TruScreen" is the cervical cancer detection machine—a lightweight box with a handpiece attached. It is designed to be easily useable anywhere, including in a GP's rooms. Its operation is so simple that it can be used with minimal training if no doctors are available. As a small article of hand luggage, with a battery powered option, it can easily be taken to any undeveloped part of the Third World, where it can provide a quality of screening equal to the best available in Sydney—or Tokyo, New York or Europe. "SolarScan" is a similar device applying the same principle to the simpler aim of skin cancer detection. "MediScan" is a digital medical imaging system, which can be programmed to detect and analyse a vast array of indicators for a variety of pathological conditions. It can be set up in a doctor's surgery to provide advanced diagnostic technology on the spot, without the wait and expense of pathology labs and specialist referrals.

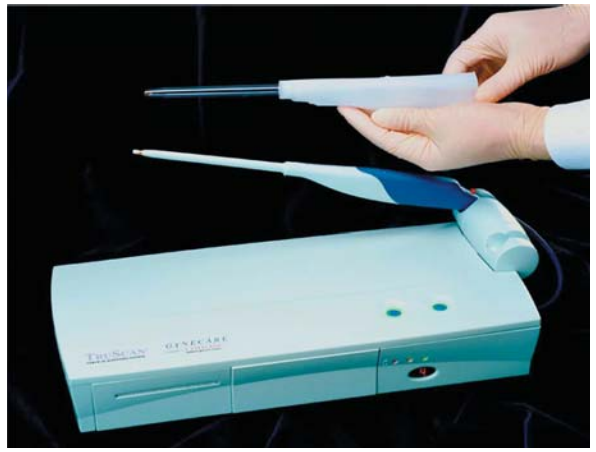
Consistent with its emphatic belief in itself, Polartechnics manages all the research, production, promotion and marketing of its products. Components, made by sub-contractors in various states and overseas, are assembled and quality tested in Sydney for international sales.

The three devices have gone on sale commercially in Italy and will soon be available in Australia and most other countries. It seems only a matter of time till they displace less sophisticated technologies all over the world. Polartechnics' novel approach can be applied to many more medical problems than the existing devices tackle; for now it is concentrating on limited areas, but in future more and more conditions are likely to come within its reach.

the embryo died early. An English team using some of the Monash techniques succeeded in 1978 with the first live human birth from in vitro fertilisation.

In vitro fertilisation is a process of immaculate conception which involves fertilising an ovum from an ovulating woman in a glass vessel with donor sperm, to produce an embryo to implant in the womb after cell multiplication begins.

A similar technique, which allows an infertile woman to give birth, involves implantation of an embryo formed with a donor mother's ovum. This succeeded in 1983, after in vitro fertilisation by the Monash team, including Alan Trounson, Carl Wood and John Leeton. The same team also brought about the first multiple birth from in vitro fertilisation, in 1981, and in 1983 the first successful implantation of an embryo that had been deep frozen. While these achievements were world firsts with human beings, twenty-three years earlier Neil Moore at the University of Sydney had transferred frozen embryos of sheep, demonstrating experimentally the feasibility of storing and implanting viable embryos.



The cervical cancer detection device, TruScreen, being manufactured in Sydney in 2003 for international distribution.

Also in the 1970s researchers were busy developing genetic engineering techniques for medicinal purposes, such as the synthesis of relaxin, already mentioned. Another team, at Sydney's Garvan Institute, fused an antibody-yielding cell from a mouse's spleen with a myeloma cell that had the property of unlimited growth. By 1980 their cell cloning technique was producing an endless supply of antibodies and in subsequent decades it has been adopted around the world.

Genetic engineering got a shot in the arm in 1987, when a CSIRO team in Canberra—led by Jim Haselloff and Wayne Gerlach—invented gene shears. The researchers made synthetic RNA molecules—"ribozymes"—which hybridise so they can cleave to the target RNA of the gene being modified or destroyed. Another region of the ribozyme has a catalytic action which destroys the target molecular structure. The technology was patented in 1989 and licensed to a French seed company. Gene shears are now routinely used all over the world, to engineer new organisms and resistant strains and to combat genetic diseases and viruses. In the 1990s they played a vital part in developing the many genetically modified crops, livestock and micro-organisms that are now at the centre of heated debate amongst consumers, environmentalists, industry groups and farmers.

At the beginning of the twenty-first century, there is a general uneasiness about much of this new technology. But community acceptance may have limited influence on the interests of scientists, who require funding, and the multinational "agribusiness" and food producing firms, which rely on continuing government cooperation.

Opposition to genetic biotechnology reflects three main areas of concern. One stems from ethical philosophy or religion, expressed in objections to tampering with natural life. Proponents of the new technologies argue that such objectors should accept the inevitabilities of progress.

Another is the widespread fear, especially amongst consumers, that the new technology will have yet unknown harmful effects. It is seen as unnatural and therefore unwholesome. This is evident in the general belief that genetically modified produce should be identified as such through mandatory labelling. Science and business condemn this objection as irrational and economically disadvantageous.

The third major thrust of opposition is based on the concern that Australian agricultural produce will lose value if it is genetically modified, so that while the chance still exists, Australia should protect itself from the new organisms in its own economic interest. Against this it is argued that Australia's economy is just a part of the global economy and that it is not appropriate to shelter local producers in such a way.

The full arguments on each side are more complex than can be acknowledged here. But if this debate, going on in the early years of a new century, is compared with the accomplishments of science in the 1970s and 80s, an imbalance is clearly emerging. Australia has been good—gifted in fact—at scientific progress but often slow in developing its philosophical and political response. The community has no way to keep pace with the innovation. By the time the issues are resolved, the technological changes will have taken effect for better or worse. Any enlightenment we gain will be of no more value than the belated enlightenment we now have on the wisdom of introducing rabbits.

AGRICULTURE

Genetically modified crops have caused concern partly because of the difficulty in isolating them. Modified varieties will seed and spread next door so that farmers preferring to market their produce as "GM free" may not be able to. Another fear is that new resistant strains will stimulate development of super pests and pathogens in a vicious circle that cannot be controlled.

But there are two sides to this question. Chemical pesticides are frequently defeated by new immunities as it is, and less reliance on them would be economically and environmentally beneficial. Some effective pesticides are being produced with genetic engineering technology, a process that Australia joined in the 1980s. For instance, Allen Kerr and his team at South Australia's Waite Agricultural Research Institute created a new pesticide, by breeding genetically engineered bacteria, released in 1989 under the label "No Gall". It has proved effective in protecting horticultural crops from gall (insect larvae, mites or fungi) infections.

Since the 1970s a reaction against artificial technologies has prompted some farmers to aim at ecologically sustainable practice on their land, under the banners of organised movements, including organic farming and macrobiotic farming. These are built in to registered trade marks so that certified farms can label and price their produce accordingly.

One of the strictest of these new movements—Permaculture—is an integrated approach to sustainable land management. Its founder, Bill Mollison, is a Tasmanian who worked in the 1950s and 60s for the CSIRO and for fisheries authorities. His book *Permaculture*, published in 1978, introduced the world to permaculture.

TILLAGE

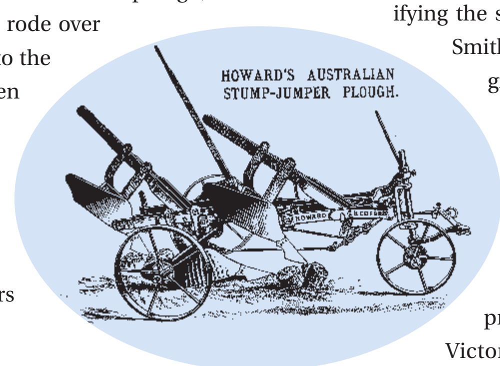
Above: *Stump jump disc ploughs near Tamworth in 1915. Generally disc ploughs are efficient and economical. In this photo they are part of a remarkably labour intensive process for cutting a furrow.*

Exponents of these reactionary farming movements have made interesting observations on alternatives to frequent ploughing, because of their concern that excessive tillage has been breaking down soil aggregates. Their practice of sowing without first turning over the topsoil has a precedent in the colonial period, known as mullenising, after Charles Mullen (or Mullens), an Irish-born farmer living in South Australia. Mullen was not worried about the harm done by excessive tillage; his problem was preparing land that had formerly grown deep-rooted mallee scrub. The labour and expense of grubbing the land and bringing it under cultivation were daunting or prohibitive and so, in the mid-nineteenth century, he worked out a relatively easy procedure. His hasty grubbing left in too many obstructions for conventional ploughing; instead the final stage involved a horse dragging all over the field a device called a mulleniser. This was a large piece of wood tapering to a point at the front, with spikes projecting from the bottom which broke the soil up sufficiently to sow a reasonable crop.

Farmers gave their mullenisers up as soon as proper ploughing became feasible. It did so thanks to the stump jump plough, invented in South Australia in 1876 by Robert Smith (1838–1919), a pattern maker and farmer, helped by his brother Clarence. The shares of the new plough, whenever they struck obstructions, rode over them harmlessly then settled back to the correct depth. Smith must have been able to see what a step forward his principle represented: in 1877 he obtained a provisional patent. But others, including Clarence Smith, were derisive. Robert wrote to a friend of the plight many inventors know well:

> My invention has cost me some money, some anxiety and condemned my little ones to all the miseries of poverty and banishment to the bush. If I had been a successful cricketer, good bowler, or a rifle shooter, without pluck, a Blondin or an acrobat, I and mine would have escaped these ills.

Perhaps because of financial straits, he let the patent lapse. A multitude of manufacturers set to work making and modifying the stump jump plough, with no gain to Smith. But in 1882 the colony gratefully granted him a £500 bonus and a block of land.



Below: *British manufacturers, including Howard's of Bedford, were quick to incorporate the stump jump principle on implements made for export to regions being newly brought under cultivation, including Australia.*

The stump jump principle was applied to other implements. But early in the twentieth century, disc ploughs from America threatened to supplant the Australian product: that was until James Garde in Victoria invented the Sundercut Stump Jump Disc Cultivating Plough. The Sunshine Harvester works began making these in 1906. Ultimately stump jump ploughs got as much use in America as they had in Australia.

A radical departure from the disc plough is the rotary hoe invented by Cliff Howard (1893–1971) in rural New South Wales. A full-scale prototype was trialled near Gilgandra in 1919. The rotary hoe is now a familiar cultivator worldwide. Its raked L-shaped blades mounted on a rotor are energy efficient and very effective in working the soil.

SOWING AND HARVESTING

In 1914, at the Henty Show in the New South Wales Riverina, local farmer Headlie Taylor demonstrated his invention the "header harvester", a machine that cut off the heads of wheat crops rather than beating them off. It had a simple movement pattern for the harvested crop and, with its adjustable cutting level, could recover fallen and tangled crops. Hugh McKay, of Sunshine Harvester fame, bought Taylor's patent rights and put him in charge of harvester production at his Sunshine works. Refinements and further developments at Sunshine up until the late 1920s gave the world equipment that replaced the Sunshine Harvester in most areas and is essentially the same as is used to this day for large-scale cereal harvesting.

Made possible by Australian invention, automated harvesting of sugar cane has taken over from back breaking manual labour in recent decades.

One of the most under-recognised world firsts is the spring tine drill cultivator, invented in 1916 by New South Wales farmer Raimond Squire, of Quirindi. It was the first of the modern seed drill ploughs, which combine cultivating, drilling and harrowing in a single operation. Seeds mixed with fertiliser are dropped at the ideal depth into a prepared seedbed, improving crop health and reducing seed and fertiliser consumption. Drill ploughs were first used in ancient times in Mesopotamia, but they ploughed and planted only one or two furrows at a time. Squires's invention is far more complex. To work successfully it needs precise engineering and careful manufacture because of the combination of operations and the multiple tines required. Hugh McKay bought Squires's patent rights too, and mass produced the new machinery at Sunshine.

SCIENTIFIC ADVANCES

The catalogue of Australian agricultural firsts could go on for volumes. Overseas there have been a few breakthroughs of greater moment—for example the propagation in China eleven centuries ago of rices that yield multiple harvests each year. But no overseas region has ever contrived as many important innovations in such a short time as Australia has.

So far we have only considered here machinery for cereal crops. Yet Australian equipment—such as sugar cane harvesters that replaced manual labour in the 1960s and 70s—has led the world in many fields. And ingenious inventions of a non-mechanical sort are equally plentiful—including a widening array of purpose-bred legumes (plants that fix nitrogen in the soil), such as clovers and sub-clovers. The twentieth century has also given us many livestock vaccines. The anthrax vaccine was isolated by John McGarvie Smith (1844–1918), who revealed his secret formula in the nick of time before he died. The cattle tick vaccine—the first by which livestock can be immunised against an external parasite—was produced in the 1980s by a private firm and the CSIRO Division of Tropical Animal Science.

Indeed, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has been at the forefront of science since it was set up as the Council for Scientific and Industrial Research (CSIR) in 1926. Originally it concentrated on research in primary industries, which is why it has succeeded so well with new plant strains and vaccines. However, since World War II, the CSIRO has also pioneered radical new developments in the industries that process Australian produce, such as metallurgy and textiles. Increasingly its work also achieved breakthroughs in the laboratories and observatories that moved science forward.

Alan Walsh, helped by colleagues at the CSIRO's Chemical Physics Division in Melbourne, invented the atomic absorption spectrophotometer, which can detect the concentration of any element in practically any medium, by measuring absorption of light rays. Chemical analysis previously had to rely on emission spectroscopy, which requires intense heat and works only for certain elements. Walsh conceived the new principle in a eureka moment, in his suburban garden in 1952. Two years later the completed machine was publicly demonstrated.

Work done in the 1940s in the CSIR's radio physics laboratory, under the direction of Marston Beard and Trevor Pearcy, gave it a head start in computer science. Information technology had an early entree to the organisation because its foundation chairman, from 1926 to 1946, was Sir George Julius (1873–1946). As an engineer who came from Perth to Sydney in his thirties, Julius had set out ambitiously to build the first automatic totalisator, a device that recorded bets and calculated dividends. He first installed one in 1913 in New Zealand where his father was the Anglican archbishop. Soon he was making them for Australia and many other countries and in 1932 he added a facility for computing odds instantaneously.

Totalisators were big enough to occupy small buildings, but they were just as quick and reliable in handling a high volume of operations as the computers of the late twentieth century. They survived in regular operation into the 1980s, their sturdy mechanisms outlasting generations of modern computers.

CSIR's work in the 1940s was technologically far ahead of the totalisator, and by 1949 they had "CSIRAC", an electronic computer with stored memory, which remained in operation until 1964. Commitment of resources to develop it was a visionary anticipation of future trends in information technology. But in 1956 the CSIRO cancelled its computer project, a move denounced by some observers. They claimed that Australia had the first computer and that to pull the plug on it was typical of the sort of short-sightedness that prevents Australia from capitalising on its innovative faculties.

Strictly speaking, though, the earliest known computer is a mechanical one, discovered in a shipwreck off the Greek island of Antikythera. When the ship went down, this remarkably sophisticated machine was set for a date 2,029 years earlier than CSIRAC's invention. It was about the size of a modern laptop, and could perform only a few functions—but it was no mere calculator. Differential gear trains enabled it to combine data from separate inputs, a capability that did not return to the Western world, even experimentally, till the nineteenth century. The first fully electronic digital computer, Z2, had been finished in Germany in 1939 by Konrad Zuse. America's first was John V. Atanasoff's, soon afterwards.

The CSIRO's considered decision to cut off the computer project was made after failed attempts to engage private and government interests. It at least had the benefit of freeing resources in the Radiophysics Division for another project that was producing spectacular results. This was the world's leading radioastronomy programme, managed by the physicist Joseph Pawsey (1904–1962). In 1945–46 Pawsey's team had established the first astronomical interferometer on Collaroy Plateau, above Sydney's Northern Beaches. Interferometers are useful only if they can register radio intensity over a large extent. In this position some antennae could pick up radio waves bounced off the ocean to collate with those reaching the interferometer directly from outer space. Interferometers use antennae to locate sources of radio waves reaching the Earth from space and giving scientists information about celestial phenomena not fully revealed through optical telescopes.

A radio telescope dish outside Canberra.

The seaside interferometer was superseded in a massive construction programme that produced the first cross interferometer, the Mills cross, designed by Bernard Mills and installed at Fleurs near Sydney in 1953. Its antennae were arrayed in two intersecting lines, each arm extending 1,500 feet. The larger Mills cross opened by the CSIRO and the University of Sydney at Hoskinstown, New South Wales, has superseded it. Another scientist at the Radiophysics Division, Wilbur Christiansen, designed the Chris-cross interferometer—a linear array alongside a body of water which receives signals only from one direction and is used to narrow down their source area.

The 64-metre radio telescope dish at Parkes, New South Wales, was commissioned in 1961. Of the various other facilities distributed throughout New South Wales and the ACT, the most ambitious is the Australia Telescope opened in the late 1980s to study supernovas. It comprises five 22-metre radio telescope dishes mounted on a railway at Culgoora, New South Wales, and three outlying dishes. It was designed by a team in the Radiophysics Division led by John Brooks and Bob Frater.

> A BREATH OF HOT AIR

In the 1890s electric light was becoming increasingly familiar in Australian cities. Melbourne got electric street lights in 1894; Hobart in 1898. But it was still exceptional, and most Australians were so familiar with lighting by oil, kerosene and gas that few would have expected to witness the end of them.

Their future looked very bright to some in 1898 after G.W. Lee and F. Elliot announced new technology for making light from ordinary air. Lee and Elliot demonstrated their amazing process in a showroom on Sydney's Elizabeth Street, explaining that they used chemicals and special equipment to convert the air into an ideal gas for lighting. They lodged a patent application and started the Atmospheric Gas Co.

The partners persuaded the New South Wales Minister for Public Instruction, Labour and Industry to become the company's chairman and shares were keenly traded. What the public didn't realise was that when Lee and Elliot demonstrated their process, a concealed operator had been working equipment in the adjoining room, fraudulently making the demonstration appear successful. When it finally became clear that there is no viable way to make air into illuminating gas, prominent members of the community had lost a bit of money and a lot of face. As for Lee and Elliot—apparently they were in Canada by then.

By the 1980s petrol motors were guzzling more and more of the world's limited oil supply and many Australians predicted the exhaustion of petroleum reserves within a generation or two. In 1982 an entrepreneur named Stephen Horvath came forward with an imaginative solution. He explained that he could make car engines which would run on water. Water—being a compound of hydrogen and oxygen—had already been considered as an energy source by experts in Australia and overseas. In China vessels that directed a jet of steam onto live coals were in industrial use 1,300 years before, making extra-hot fires by releasing hydrogen on contact.

However, scientists commented that the huge plant required to fuel an internal combustion engine this way had no prospect of fitting in a road vehicle, and the new project was condemned throughout the southern states.

Courier Mail *cartoonist Shakespeare made fun of Joh Bjelke-Petersen's faith in characters who may not have deserved his trust.*

In Queensland it received a more tolerant hearing. The state government declared its support for an initiative that heralded the future age in motoring. The government's confidence was rewarded in 1983, with an opportunity to demonstrate to a sceptical world just what a water-burning car can achieve. For the first public demonstration in Sydney, Horvath supplied a vehicle that looked outwardly like an ageing conventional car. A jubilant premier of Queensland, Sir Johannes Bjelke Petersen, ostentatiously poured water into the tank as the cameras rolled. He then took the driver's seat and turned the key.

The car of the future performed just as a conventional car would if its petrol tank were full of water. When it failed to go the Premier looked around for Horvath but he was elsewhere. The Queensland government quietly cancelled the project.

Radioastronomy equipment and scientists have enabled great advances in astronomy and physics by improving knowledge of outer space. With the seaside interferometer it was discovered that the Sun's radio intensity fluctuates inconsistently with its brightness and is linked to sunspot activity. In 1946 CSIRO physicist R.G. Giovanelli was able to explain the phenomenon of solar flares in the vicinity of sunspots. In 1949 J.P. Wild designed the first radio spectrograph, which detected different kinds of solar bursts by taking aerial measurements of solar radiation.

The Parkes telescope and the Mills cross at Hoskinstown near Canberra have detected a multitude of pulsars since 1960, and in 1963 readings from Parkes located radio source 3C 273—the first known quasar, as revealed by comparisons with optical observations in America. In 1969, when America's *Apollo XI* landed men on the Moon, live television coverage relayed through the Canberra Deep Space Communication Complex and the Parkes radio telescope were screened throughout the world.

FACILITIES AND APPARATUS

Australia's southern hemisphere location has made it an important base for optical astronomy as well, with a string of discoveries dating back to the nineteenth century, such as Tebbutt's Comet identified in 1861 by John Tebbutt (1834–1916). Since William Dawes opened the first permanent observatory at Dawes Point, Sydney, in 1788, Australia has been relatively well endowed with stargazing facilities and optical instruments.

It took longer for facilities to develop in other fields. After a while, a handful of scientists had private laboratories. Those, and small research facilities attached to a few museums, hospitals, factories and universities, were almost all we had until well into the twentieth century. In 1888 people agitating for better provision for science formed the Australasian Association for the Advancement of Science. An active member a hundred years ago was William Henry Bragg (1862–1942), a mathematics professor at Adelaide University who had come from Britain in 1885. He worked for the improvement of science and science education, and one of his initiatives was to build X-ray equipment, soon after its invention in Germany. As a schoolboy in Adelaide, Bragg's son, William Lawrence Bragg (1890–1971) broke his arm and became the first patient in Australia—if not the world—to have an X-ray examination.

In 1908 father and son went to England. Working together, they discovered that X-rays could be used to analyse crystalline material and developed the science of X-ray crystallography. In 1915, Bragg junior achieved another Australian first: he became a Nobel Laureate (the world's youngest) when he and his father shared the prize for physics in recognition of this work.

He was not the first, however, to demonstrate Australia's flair for inventing analytical devices. At the University of Melbourne in 1906 Kerr Grant and B.D. Steele invented a balance that could register a thousand millionth of a gram—far more sensitive than any other equipment at the time.

The atomic absorption spectrophotometer mentioned earlier was followed by the flame ionisation detector, invented by Ian McWilliam in 1957. McWilliam and Ray Dewar worked at the ICI Australia research laboratory to develop a patentable commercial model—which went into full-scale production in 1962. It measures organic impurities in gases by causing organic compounds to ionise in flame and registering the electric current that results. It was quickly adopted internationally, for pollution measurement, drug testing and chemical manufacturing.

In the 1960s researchers in Australia and overseas were working on molecular analysis of proteins by recognition of their amino acids. Research was most advanced at Melbourne's St Vincent's Hospital where Per Olaf Edman, a Swede who had moved to Australia, invented the sequenator.

Something really novel in chemical analysis was developed in Sydney in the 1980s by the Australian Nanotechnology Research Institute: the minute synthetic molecular machine, AMBRI (see page 12). It works rather like the naturally occurring antibodies that detect impurities in the bloodstream.

INDUSTRIAL FIRSTS

Many inventors named so far were boffins in laboratories, at a certain remove from the mundane world. Nevertheless, a distinctive characteristic of Australian science is its strongly practical disposition. Progress in astronomy and astrophysics relies on curiosity about our universe—which makes these sciences exceptional. The same goes for prehistory. Of course, plenty of scientists at the universities pursue knowledge for its own sake, but when conspicuous achievements mark Australian science as a world leader, they usually advance knowledge only in the cause of advancing utility.

Progress is most impressive in industries that exploit domestic products. Because of the value of the wool clip our textile industry is particularly advanced, having introduced many new methods for spinning, shrink proofing and permanent press fabric. Wool has retained a place in markets flooded with new synthetics thanks to innovative products such as “cool wool”, based on a yarn twisting process worked out at the CSIRO’s Division of Textile Industry in Geelong in the 1970s.

In 1979 and 1980 advertisements for Holeproof’s patented “computer sock”—which “falls up, not down”—flooded newspapers and television screens. Elasticity varies up and down the sock—with the greatest concentration of Lycra at the ankle, and none at the top—so that the elastic forces tend to balance when the sock is in the right place. This technology remains in worldwide use, although it isn’t apparent on everyone. The computer was given the credit solely for marketing reasons—it was actually invented by Maxwell Wilkinson, Jeffrey Lee and Malcolm Patton.

The Optim wool fibre processing machine, designed by Invetech Operations. Introduced in 2001, it is the manufacturing apparatus for the latest enhancements to wool fibres developed by the CSIRO and the Woolmark Company. It produces luxurious lightweight fibres suited to all seasons, and is one of many Australian developments that boost the value of our wool clip by keeping wool and wool blends a few steps ahead of synthetic fibres.

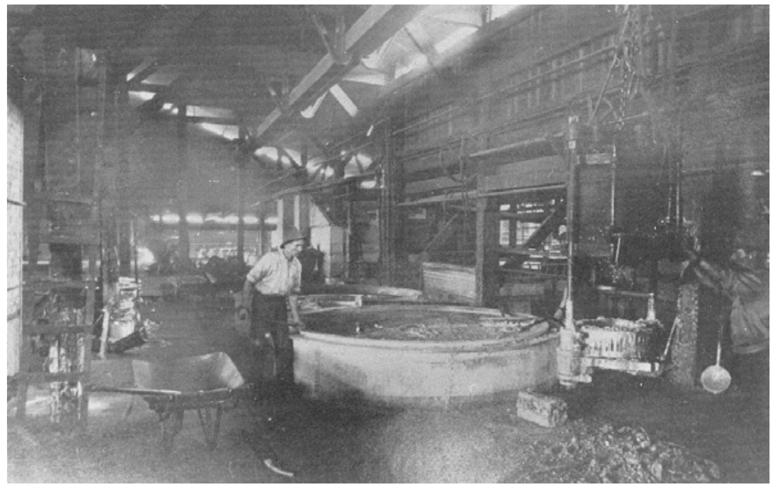
Below: *The Computer Sock of 1979. It had nothing more to do with computers than an ordinary sock.*

Not surprisingly, mining and metallurgy have long been areas of practical strength for Australian science. Extraction and smelting processes developed by private industry and the CSIRO have made it possible to exploit low-grade ores and cut costs. For example, CRA’S Hi-smelt process—developed in Kwinana, Western Australia, by John Innes and Richard Turner—puts the smelter’s off-gas to practical use in maintaining the heat of the smelting bath and by combining it with ore being fed in so that it contributes to reduction of the ore.

Australia’s most important contribution to minerals extraction technology is the flotation process, invented in 1903 and developed throughout the period before World War I. Lead mining at Broken Hill had left huge tailings dumps, rich in zinc. Working out how to separate the zinc from the tailings and from ores would unlock great wealth, and many minds were occupied with the problem. Guillaume Delprat (1856–1937), a Dutchman who was BHP’s general manager at Broken Hill, thought it might be possible to dissolve the zinc by boiling the tailings with salt cake. But instead of dissolving, zinc particles rose to the surface, attached to bubbles formed by the salt. When BHP’s technicians reported this “failure”, Delprat recognised it as a breakthrough and set up a pioneering flotation plant.

By then, Charles Potter (1859–1908), a consulting brewer from Melbourne, was already operating a flotation process. He had added sulphuric acid to form bubbles in a bath containing Broken Hill tailings, and licensed a company to go into commercial production at the Hill. Potter took BHP to court for infringing his patent and lost the case after four years’ litigation—chiefly on the grounds that his patent did not disclose a sufficiently practicable method. Afterwards, though, BHP went over to sulphuric acid instead of salt. The method is known as the Potter-Delprat process. Metallurgists in several countries patented a series of improvements. In 1912 a carpenter and foreman at Broken Hill, F.J. Lyster, invented and patented a selective flotation method, which greatly streamlined the separation of different contents—in this case, lead from zinc.

Australian inventors have also been notably successful with new materials. One of the most exciting is stabilised zirconia ceramic, invented at the CSIRO’s Advanced Materials Laboratory, and patented in 1978. The unique zirconia chemical composition prevents any crack that forms from spreading more than a short distance. Its resistance to fracture is potentially revolutionary.



Zinc being separated from tailings at BHP’s plant, by the Potter-Delprat process. Flotation technology developed in Melbourne and Broken Hill a century ago is economically Australia’s most significant contribution to industrial technology.

An invention that began to have a noticeable effect on daily life in the late 1990s is the “ReVinyl Bottle”, made from recycled PVC plastic. It was first released in 1991 by the Melbourne firm Peteron Plastics for use as a beverage container.

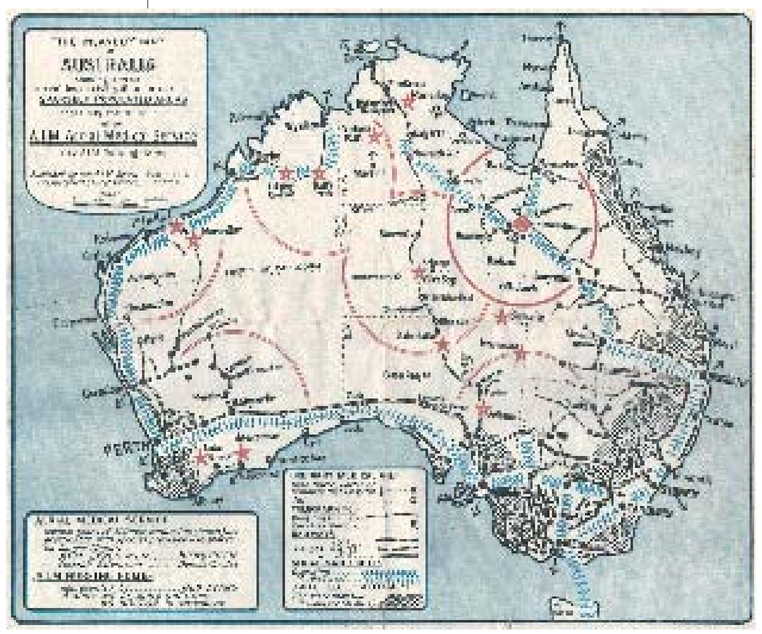
This and other inventions reviewed here are just examples of patents that have potential to advance industry in economically significant ways. Scores at least have been granted every year in the last century. Such industrial inventiveness often prompts comment on the limited enterprise and shrinking ambition of Australian industry and some critics have spoken of Australian manufacturers as “conservative and risk averse”.

For decades there has been a steady outflow of Australian ideas, capitalised on by investors and manufacturers overseas. Yet on the whole our manufacturers and investors are no more faint-hearted than their overseas counterparts. Some of those considered in this book are conspicuous for boldness and vision. So the conservative and risk averse posture is surely not due to individual weakness of judgement; it must be linked to structural limitations in our economy, society and/or system of government. When the doors open to innovative thinking about these fundamentals we can look forward to seeing these handicaps overcome.

THE TAMING OF DISTANCE

“Distance is as characteristic of Australia as mountains are of Switzerland,” wrote Geoffrey Blainey in his preface to *The Tyranny of Distance*, first published in 1966. “Most parts of Australia are at least 12,000 miles from Western Europe. The distance of one part of Australia from another was and is a problem as obstinate as Australia’s isolation from Europe.”

The mighty array of twentieth-century communication tools—cables, telex, faxes, e-mail, radio, satellites, optical fibres and broadband—have accustomed us to hearing about one communications revolution after another. But the revolutions of the last century diminish in significance when one thinks of 1872. In October that year the Overland



Modern amenities in remote areas, a map produced in 1929 by John Flynn’s Australian Inland Mission. The circles and arcs mark out the regular zone of operations of the Flying Doctor. This service was a world first, made possible by Alf Traeger’s work on wireless communication.

> THE CUTTING EDGE

As young banana growers on the New South Wales North Coast, Angelo Notaras and his brother John quickly discovered the benefits of putting mechanical equipment to novel uses. For instance, they were the first to use centrifugal pumps for banana irrigation, drawing water up lifts once considered far too great except for piston pumps. They also invented a highly effective new crop spraying system. They increased production several times over, establishing practices still followed on banana farms.

However, they became so absorbed in machinery that in 1960 they left the farm and set up a workshop in Sydney. By the late 1960s their company Atom Industries had a small factory, making only their own inventions. The mainstay was a heavy-duty drill that can be attached to a chainsaw. The Atom drilling attachment is still as popular as ever, and nine-tenths of Australia's rural fencing is built with its assistance.

The Notaras brothers realised they could invent a chainsaw far more advanced than the European models that dominated the market. Features that made it superior included a self-cleaning air filter, a carburettor that plugged into a seal, turbo-charging electronic ignition and a longer, trouble-free working life. The Commonwealth Government encouraged the brothers to develop the chainsaw for commercial production. In particular, the support would see them through the first critical years—while they found export markets to boost volume and convinced customers of the advantages of invisible features such as the air filter.

The saw went into commercial production in 1972. But a few months later, in 1973, the tariff was halved, which put an end to the domestic market for the saw. At about the same time, the Australian dollar was revalued sharply, so that export sales were no longer possible. It was a heartbreaking combination. Atom Industries stopped production immediately and took all the specially made tooling to the scrap heap.

Thirty years later European saws have finally caught up with the ill-fated Australian chainsaw. All the dearer European models are now being fitted with self-cleaning air filters and other improvements like those invented by the Notarases, whose patents have expired.

Above: *An Atom drilling attachment fitted to a conventional chainsaw makes easy work of a hardwood post.*

Below: *The award-winning lawn edger.*

A far more successful venture is the Atom range of motorised lawn edgers, launched in 1994. Lawn edgers then were slow and difficult to use. The Notaras brothers had the idea of making a two-handled edger that could be steered around the garden as easily as an empty wheelbarrow. In the last few years it has captured market dominance in Australia, ousting both dearer and cheaper imports.

One of Atom's new ventures is a recently patented two-stroke engine. The conventional modern two-stroke—invented over a hundred years ago—produces a high volume of toxic fumes and wastes petrol. By using air to displace the exhaust the new engine will be cleaner and more economical.

Angelo and John work together on all their inventions. Often each will go home, after a day considering a problem, and think of a solution that night. Meeting again next morning they'll discover that both have independently reached identical solutions. John keeps a pad at his bedside and sometimes wakes to record an inspiration.

Most of their innovations are not eye-catching new machines but clever improvements to existing products. For instance, in place of a conventional chuck for their drill, they invented a ring with a screw through it, which is cheaper to make but holds the drill bit tighter with use, instead of working loose like a chuck.

Atom Industries holds dozens of patents and design registrations covering a range of innovations. However, they decided not to patent their "augur stop", which is standard on Atom drills. Whenever a knot of timber, an old bolt or some other obstruction causes the drill to jam, the augur stop switches the transmission into neutral, stopping the motion instantly. Drills are much safer with this feature, which could easily be engineered into a wide range of other powered machinery. Because of its potential to improve the safety of millions of workers, the Notaras brothers preferred to make it freely available—just as John Ridley declined to patent his stripper (see page 8) from a desire to benefit the community.

A recent innovation is an ingeniously simple centrifugal clutch, developed for electric lawn edgers. Direct drive is standard around the world for light and medium electrical machinery. Adding a clutch radically reduces breakdowns and prolongs the life of the motor.

When they try to sell their new technology overseas, John and Angelo routinely find that major manufacturers would sooner stick with existing procedures than introduce improvements developed by little-known outsiders. As a result, most of the superior technology in their mechanical products remains unique to Australia. Curiously, though, Australian manufacturers rarely take the opportunities presented by Atom's innovations. The clutch, for example, could readily be adopted in all sorts of appliances and tools to give Australian products a quality advantage. Angelo suspects that experts working for some manufacturers are reluctant to concede that they could have been doing better all along with something they didn't think of. That may be easy to say, but it underlines a problem repeatedly faced by Australian inventors: their difficulty in getting attention and credence, without vast resources for sales promotion of their ideas.

The brothers often win awards for innovation, which can be a useful aid in promotion. A wall at Atom Industries' modest inner Sydney factory is crowded with them. Amongst them are the Mechanical Engineers of Australia Product of the Year award, four years running from 1994 to 1997, for various lawn edgers; and the 1976 Inventor of the Year Award for the Atom electric ignition system.

Frequently inventions aimed at making better, more durable products lead to significant cost savings, and vice versa. At the moment the two brothers are working on a plan to reduce from seventeen to eight the number of pieces in the assembly at one end of the lawn edgers. This could take dollars off the manufacturing cost. Like many simplifications in assembly techniques that they have worked out over the years, it will speed up their output.

Above: *John (left) and Angelo Notaras, amongst inventions and accolades.*

When Australian manufacturers have to compete with those in other countries, it is not good enough for them to be equally efficient, or able to match the quality of an import at equal price. They have to do *better* just to be able to survive. Astonishing though it sounds, Australia's tariff regime operates to protect overseas manufacturers from local Australian competition. For example, if Atom Industries imports an engine for one of its lawn edgers, it has to pay duty. But a lawn edger made in America with the same engine comes in duty free. In this way Australian manufacturers are effectively forced to subsidise their overseas competitors, to the extent of hundreds of millions of dollars every year. In recent decades, many have shut down their operations; and, saddled with this handicap, many others will have to do so as time goes on.

Thanks to on-the-spot ingenuity, Atom Industries is too far ahead of the competition to be immediately threatened. But in the long run all such enterprises are vulnerable to foreign takeovers followed by transfer of their plant to other countries so that "high" Australian wages need not be paid.

Telegraph began to carry international messages. Communication times with Western Europe went from a few months to a few minutes. Since then innovations in telecommunications have been a plethora of small steps. Increasingly these have been Australian initiatives.

Alf Traeger invented his pedal wireless transceiver—a convenient low-maintenance, two-way set—in 1925. A few years later, when it was distributed in numbers to outback homes, the transceiver put them in touch with the Royal Flying Doctor Service, another Australian innovation devised to tackle the isolation of the outback by providing emergency medical assistance. In 1951 the School of the Air was launched, taking advantage of the transceiver sets in remote areas.

Extension of phone services to the outback in the 1980s and 90s relied heavily on Australian invention. Much of it comes from the Telecom research laboratories in Melbourne. Telecom (now Telstra) is one of the leading pioneers in world-wide digital communications, its digital radio concentration system having enabled clear transmissions over long distances, with minimal infrastructure and power supply. In connection with the world's first solar-powered phone system, this new technology came into operation in 1978, beginning with a phone at Wilkatana in South Australia. In the 1990s, Telstra perfected ADSL, a system that relies on the high capacity of copper wire to carry transmissions to individual subscribers' phone and modem systems from optical fibre mains.

Impressive as these telecommunications systems are, they are a small investment compared with the transport networks that service Australia and link it to the outside world. Australia has amongst the world's greatest route mileages of railway and roads per capita and local ingenuity has produced some noteworthy innovations.

Sydney's "SCATS" integrated traffic control system, introduced in the 1960s, is an important example. It monitors traffic flows and regulates signals so that a badly designed old road system can handle the heavy traffic volumes of a large modern city. Like SCATS, railway bogie exchange stations counter the effects of poor early planning—eliminating costly trans-shipment by swapping bogies on railway wagons so that they can continue their journeys across breaks in rail gauges.

Mostly though, land transport networks are constructed according to imported technology. Australian firsts are more apparent in sea and air transport.

SHIPS

Australia relies overwhelmingly on foreign-owned, foreign-built fleets but it has been a surprisingly fertile source of nautical innovation.

In the 1870s, the first refrigerated ships were conventional vessels fitted out in Melbourne and Sydney (see page 00). When the containerised system of freight transport—which now dominates world trade—was being pioneered in the 1960s, the first purpose-built, fully modularised container ship, the *Kooringa*, was completed in 1964 by the New South Wales State Dockyard at Newcastle, for the Melbourne–Perth service of the Associated Steamship Co.

Aurora Australis, built at Carrington slipways, Newcastle, was the world's most advanced Antarctic supply vessel when she was completed in 1990. She was designed by a Finnish firm to specifications worked out by a team in Australia.

A revolution in seaborne passenger travel began in 1982, when International Catamarans in Hobart launched the first wave-piercing catamaran. Designed by Phillip Hercus and a team working in Sydney and Tasmania, it consisted of a central hull carried above the water on two long slender outer hulls with inbuilt motors. Twenty years later, designs have undergone a lot of fine tuning but many of the world's new high-speed passenger vessels are now wave-piercing catamarans built in Tasmania. They are more reliable, cheaper to run, and more stable in heavy seas than the hydrofoils and hovercraft that they replaced.

AIR TRAVEL

Australia is even less important as an aircraft building country than as a shipbuilder. But the "tyranny of distance" has kept Australian ideas for improvements coming in aviation. In Sydney in 1858, Dr William Bland (1789–1868) released designs for his "atmotic ship"—an airship anticipating the zeppelins of fifty years later. Unlike the atmotic ship, Lawrence Hargrave's (1850–1915) work in pioneering heavier-than-air flight had a major practical effect. Hargrave—who had immigrated from England in 1865—owned enough property to be able to dedicate his life to the dream of manned flight. He had no idea of intellectual property or exploiting his secrets. Instead he spread the word, in long letters to every aviation pioneer he could find—including the Wright brothers in America, who ultimately commercialised the aeroplane.

> MORE FROM LESS

"Australians have always had to conquer obstacles with slender resources of money and manpower. That's produced a long line of innovative solutions," according to Steve Davies, naval projects manager at ADI. Small teams on tight budgets in Australia regularly achieve better results than amply funded large concerns overseas.

ADI was founded in 1989 when the Defence Department consolidated a multitude of government munitions businesses into a single corporation.

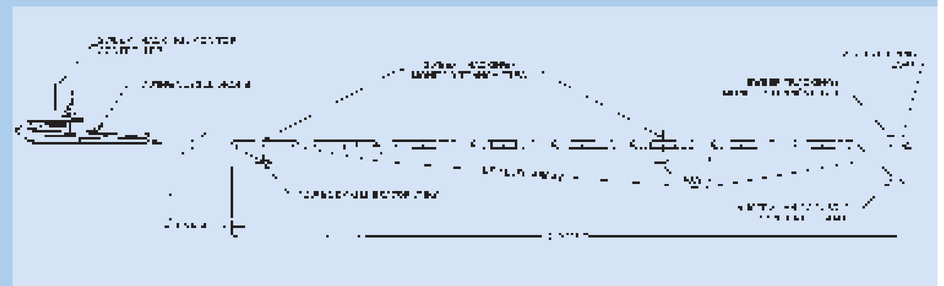
In 1998 ADI completed the first of six Hunter class mine hunters at its Newcastle shipyard. Australia instantly had a mine hunting capability many times more accurate than the next best in the world. The new mine hunter pinpoints a distant sea mine with variable depth sonar and despatches a mini-sub to plant a grenade on the mine with its mechanical arm. No single nation produces the hundreds of sophisticated systems brought together to make this possible, and no other nation has worked out a combination nearly as successful as ADI's.

However, some of the critical elements depend on local creativity. The hull and decks are made from unique advanced compounds of metals, plastics, carbon and glass fibres meticulously laid down in a hull mould in Newcastle. The result is a remarkably strong, light, quiet vessel which is difficult to detect. The software that can assimilate the positions of four independently moving objects—ship, sonar module, mini-sub and mine—was integrated by ADI and its subcontractors.

ADI's computer facility in Perth, employs about 150 software developers. Their greatest breakthrough is Llama-cheetah—a panoramic battle simulation system—to replace the big tables seen in the movies, with people using long cues to move ships and equipment around. During battle the system shows animated images of everything going on, on screens at any number of command posts. Australian commanders in the 2003 Iraq war ran their operations from Llama-cheetah stations on board RAN transports in the Persian Gulf.

In preparation for combat the system can be used for trial runs, visualising any set of circumstances. Afterwards every move can be replayed exactly.

In its endless search for the best marriage of defence technologies, ADI was impressed by the work of an Adelaide inventor who had worked on the challenge posed by latest generation of sensitive sea mines. These lie harmlessly on the bottom until they recognise the distinctive sound of a target ship, which they then rise to destroy. The solution was a noise generator—a floating capsule that mimics the sound of ships while being towed through mined waters. Outsmarted mines rise towards the surface and are easily disabled. The patents were licensed to ADI where a team has developed the acoustic generator for manufacture. It can be set to sound like an oil tanker, a fishing boat or any class of warship. ADI has also developed



ADI's minehunting system combines acoustic, magnetic and electrical monitoring techniques, in the most sophisticated and effective array ever devised.

the concept for an extra-quiet vessel built of advanced composite material, to tow the noise generator through the danger area.

A few years ago, when the Navy announced that it wanted a landing craft that could get men and equipment ashore faster than any other, some designers conceived of vessels that could travel much faster than existing landing craft. ADI was rather conservative on this score. It concentrated instead on the time taken loading craft from ships by the roll-on roll-off principle, and the unloading time on the beach.

While ADI had competitors submitting designs based on the standard NATO width, ADI proposed a slightly wider hull—just wide enough to accommodate two lanes, which load simultaneously. Being fitted with ramps fore and aft, they can head straight in to land, without having to turn the bow about. A pontoon system—for joining their ramps to those of mother ships—was designed to be safer, quicker and more stable than the orthodox ramp-to-ramp docking system. In selecting the ADI proposal, the Navy specifically commented that it was attracted to the innovative designs rather than the cheapest method.

> A.G.M. MICHELL

"Theory is the captain—practice the soldiers." Anthony George Maldon Michell (1870–1959) borrowed this maxim from Leonardo da Vinci and lived by it. After his youth at Maldon in the Victorian bush, Michell went on to study engineering at Melbourne University and Cambridge and to work on pump design for River Murray irrigation schemes. He was particularly interested in British literature of the 1880s about lubrication, and in 1905 Michell's own paper about regulation of lubricant flows was published in a German scientific journal.

Thrust bearings of that time communicated thrust by metal-to-metal contact which wastes energy in friction. The typical example is a ship's propeller shaft, which needed a series of collar bearings to refer the propeller's thrust to the ship as a whole.

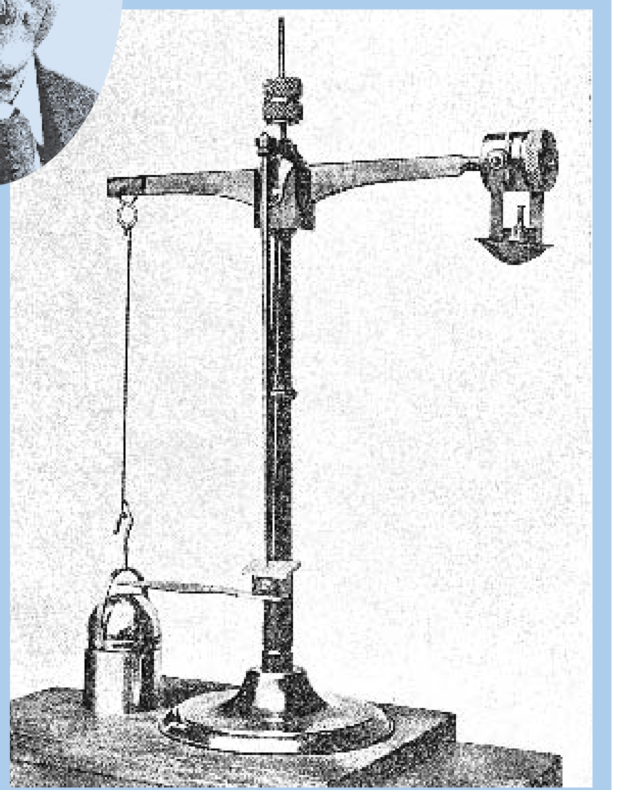
Michell's revolutionary tilt pad thrust bearing ensured that there would always be continuous wedges of oil sandwiched between the metal surfaces—one of which was formed by pivoting pads. He patented his new bearing in 1905. Then, like so many inventors, he found that no one, including the British Admiralty, would take him seriously. The idea was mostly ignored until the British Navy captured a German U-boat early in the World War I. German engineers had secretly taken Michell very seriously indeed, and their submarines were fully equipped with his thrust bearings. In 1915 the Admiralty adopted the new technology with gusto.

Applying for an extension of his patent after the war, Michell maintained that the invention had saved the Admiralty £500,000 worth of coal in 1918 alone. By then he had patented a series of inventions connected with his work and expertise—beginning in 1901 with improvements for pumps, and including a new sort of roof guttering (1916) and a telegraphic encoding system (1907). His work in lubrication led to a series of patents in the 1920s, and his book *Principles of Lubrication*, published in 1950, became a standard text for decades.

Michell's most ambitious venture was the Crankless Engine Company, intended to commercialise an engine based on his discoveries associated with lubrication and the thrust bearing. In this invention the reciprocating motion of pistons turned a shaft by means of obliquely set collars. In reverse, the same principle allowed a piston pump to be worked by rotary motion.

One of Michell's co-directors was future governor-general Richard Casey, who had some initial success trying to interest overseas firms in the new engine, with its many obvious advantages. Eventually Michell and his associates ran out of funds. Their task was simply too big, although had the Depression not set in, an overseas car maker might eventually have taken up his engine.

Altogether, Michell lodged sixty patent applications. For a while he worked as an examiner in the last years of Victoria's Patent Office, and before and after that as a patent attorney. His inventions ranged from the field of paper making to horticulture, but it is his work on lubrication for which he is justly admired and his bearing remains standard equipment on ships to this day.



A ball and socket viscosimeter—an apparatus invented by A.G.M. Michell in 1919 for measuring the viscosity of lubricants.

Two of Hargrave's inventions were vital to the early success of aviation: the box kite (early 1890s), with its lift-imparting wing structure; and the rotary propeller engine (1889). This engine had a high power-to-weight ratio, with cylinders mounted on the propeller struts. It sounds far-fetched now, but for planes it was far superior to conventional engines of the time.

Australia was one of the quickest countries to find uses for aeroplanes when they became available, and Australians pioneered as many important long-distance routes as any nation. In 1928 John Flynn (1880–1951) opened the first flying doctor service, at Cloncurry in Queensland.

In the 1950s, at the Aeronautical Research Laboratory Melbourne, David Warren invented the "Red Egg". It was subsequently developed overseas, as the now ubiquitous black box flight recorder, and has saved the lives of thousands by revealing the causes of crashes.

In aerial navigation and safety, Australian patents or firsts include systems of navigational radio beacons, glide path guidance lights, Interscan air traffic control, and airport safety monitoring. The inflatable slippery dips at aircraft emergency exits, which turn into life rafts for crashes at sea, were invented in 1965 by Jack Grant, a safety superintendent for Qantas.

DEFENCE EQUIPMENT

Much new technology for aircraft and ships has been developed for military purposes. Salisbury in Adelaide's northern suburbs is the scene of Australia's largest defence research facilities, known as the Defence Science and Technology Organisation. The laser airborne depth sounder—"LADS"—was developed in the 1970s at the Electronics and Surveillance Research Laboratory there, in collaboration with Vision Systems and BHP. Fitted to a Fokker aircraft, it profiles coastal seabeds by simultaneously bouncing laser beams off the water surface and the seabed. Readings of the time elapsed till they get back enables very accurate charting, valuable in civil and military use.

A similar technology exploiting soundwaves to detect submarines was developed at Salisbury in conjunction with Plessy, the Commonwealth Aircraft Corporation and AWA. Known as the Barra Sonobuoy, it is a canister which is dropped into the ocean from an aircraft, opens up and spreads an array of sensitive antennae. The engine noises these antennae detect are relayed to the processor in the aircraft, which calculates an exact bearing.

Salisbury is also the birthplace of the Jindalee Over-the-Horizon radar system—an early-warning system developed there in the 1980s. Work on its installation, begun in 1991 by Telstra and Melbourne communications company Radio Frequency Systems, was completed in 2003.

The latest generation of submarines was launched in Adelaide in the 1990s. Adverse publicity about the racket they make in the water testifies to the exacting standards that the Barra Sonobouy has helped to set. The publicity also obscured the positive qualities of the new subs, which carry some of the world's most advanced systems.

Almost nothing becomes obsolete as quickly as defence technology. Globally it receives the amplest resources and small modifications can tip the balance between attack and defence.

On Port Phillip Bay, the Tenix Corporation is completing its Anzac frigate contracts, and in Newcastle ADI builds advanced mine hunters. Firms like these have adopted modern-day business practices, pruning middle management and sharply increasing productivity with small teams. They have learnt to be competitive against foreign rivals, despite slender resources locally and an erratic flow of major contracts. However, these adjustments have produced new threats to Australia's defence capability. There was so little recruitment of fresh expertise in the adjustment phase that each firm's leading knowledge rests with a few individuals. A bad salmon mousse at a dinner party, or a recruitment campaign by foreign head hunters, could decimate Australia's defensive innovation capability. Tendering on the open market for new contracts is so costly and uncertain that munitions development firms face an uncertain future here.

Managers and administrators have been working on an innovative solution. Under a defence industry plan formulated in 2002, defence suppliers would join in resource-sharing partnerships to keep defence technology in Australia; the Navy would guarantee them preferential treatment in future ordering.

With modest improvements in gunnery in the twentieth century, Australians have had quite an impact on land warfare. On Gallipoli in May 1915, Lance Corporal W.C. Beech rigged up the first periscope rifle for trench warfare. Corporal Muirhead, on leave to England from the Western Front, invented the disposable machine gun belt, to stop guns from jamming. In a later war, the Owen gun, invented by Wollongong recruit Evelyn Owen (1915–1949) was initially rejected by the Army Central Inventions Board, only to become a mainstay of jungle campaigns.

MODERN LIFE

In many countries the end of World War II heralded a new era in the lifestyles of ordinary people. We still live with the priorities it brought. Consumer goods, such as washing machines and cars, became indispensable to normal life, while faith, poetry and domestic accomplishments were regarded as expendable. Social contact and live entertainment began to diminish. Telephones, television, gossip magazines, portable radios, stereos, the TAB and the Internet make it easier than ever in our post-war world to keep in touch without face-to-face encounters. And things are built to be impressively new rather than to last.

New features of today's lifestyle often reflect Australian conditions. While residents of damp northern continents saved up for electric clothes driers, Australians all got Hills hoists. They pushed new Victa mowers over their large suburban blocks, during leisure time which, before the war, might have been spent socialising at the pub or growing vegetables. Forsaking excursion trains, they put Eskies into their Holdens and Fords and went on private picnics.

A summary like this exaggerates the difference between today's life and life before the war and it also makes it too easy to think of life now as just a stable prolongation of the pattern of the 1950s. But it is true that the consumerist outlook that took root then introduced a crop of traditions that identify us more closely than before with brand names, suburban stereotypes and new technologies for our personal lives and homes.

One modern item that has become very common in the back sheds of Australian suburbs is the Triton work bench—descendant of a prototype built in 1975 by Melbourne television journalist George Lewin. As an untrained amateur carpenter, Lewin was frustrated by the difficulty of controlling his power saw—which simply refused to make an accurate cut for him and was so unstable that it was scary to use. He solved the problem by inventing in his own back shed an ingenious saw bench which offered stability and precision control.

Like many inventors who try to commercialise their inspiration, Lewin was almost ruined by the process. He was saved by a 1976 appearance on the television programme *The Inventors*, which brought a tide of orders and enquiries and which set George Lewin on a somewhat rocky road to commercial success. In 1999, hundreds of thousands of work benches later, he sold the Triton business to Hills Industries (the Hills hoist people). Mindful of his early difficulties and the critical role of television in making his fortune, George Lewin went on to establish the Triton Foundation, expressly to assist backyard inventors to turn their inventions to practical account without breaking them financially. One of its aims is to promote the inventions on television.

Above and opposite: *The Solar Sailor, built in 2000 by Advanced Technology Watercraft, is a cruise vessel for 100 passengers. It runs on a combination of solar power, wind power and LP gas.*

Some of the technologies that caught on after the war were around long before favourable conditions allowed them to become household items. Rotary clothes hoists and rotary mowers, for instance, go back at least to the early twentieth century. The now ubiquitous wine cask is a synthetic variant on the ancient wine skin, redesigned to fit easily in a portable holder. In the 1970s and 80s it completely replaced the large glass flagons of earlier times. But there were already wine casks in the 1960s. The first to have its own tap was probably the model designed in 1965 by Charles Malpas of Diemoulders in Geelong. It was marketed by Penfolds in 1968 in a tin painted to look like a barrel. In 1964, the Angoves firm in South Australia had sought a patent for the type that fits in an oblong cardboard box, but it had no tap. They originally envisaged that drinkers would snip a corner off!

DataDot Technology is an innovative firm pioneering new technology to take advantage of a basic idea invented in 1948. A "Data Dot" is a tiny adhesive disc that can be applied to any article of value, such as a car. Its function is to discourage theft and improve recovery, by marking each article with identity information. Thanks to important work done over the last twelve years, it is now possible to spray on multiple Data Dots, made of an advanced polyester substrate and laser etched with microscopic characters. The information they carry—such as vehicle identification numbers and licence numbers—can be magnified and read so that stolen goods are easy to identify and hard for thieves to sell. The dots are so small that some of them are sure to escape the notice of a criminal determined to remove them.

The same company has also developed "Data Thread", which can be woven into material and labels, carrying identification data in the same way. Although DataDot is an Australian firm, it has many overseas offices, Australian and overseas patents and relationships with crime-fighting authorities in Britain and the United States.

Exploitation of solar energy has an even longer history of progressive development. Before the war people sometimes heated water in black containers mounted in the sunlight which worked only on sunny days. In the early 1950s a team lead by Roger Morse at the CSIRO's experimental workshop in Melbourne began designing solar water heaters and studying the effect of various innovations, opening the way to future improvements. In the 1970s Morse's team developed a system enclosing the heater pipes in an insulated space between two transparent panes so that heat from the pipes would not be lost to the atmosphere. This and a range of other ideas made domestic solar water heaters cheap and practical enough to become a common feature on suburban roofs, even in cloudy cities like Sydney and Melbourne.

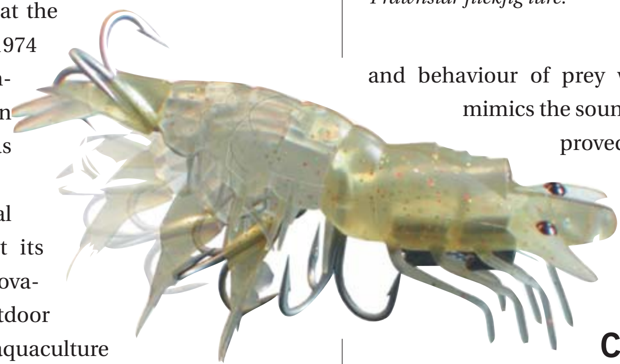
Clothes hoists and water heaters are the simplest devices for exploiting solar energy at home. The more elaborate solar apparatuses for generating electricity have not yet become efficient enough to make a major impact on daily life. But an important step came in the mid-1980s at the University of New South Wales where Stuart Wenham and Professor Martin Green invented a solar cell with recessed current tracks that do not shade the cell's surface and can be placed close together for greater absorption of electrons. These were more economical to make than earlier types and generated more power for their weight. Their effectiveness was proved in 1990 in the winning car in the Darwin to Adelaide solar car race.

Research is going on to develop cheap domestic solar generators powerful enough to supply houses in areas beyond public power grids. Meanwhile advances reducing the power required by communications systems have already made solar electricity an important feature of phone and microwave radio links to remote areas.

TRENDS IN RECREATION

Australia is a natural leader in solar energy because it is both technologically advanced and sun drenched. As we noticed before, Australians are also unusually careful about health and safety. These elements in combination account for the national preoccupation with skin cancer, expressed in regrowth of the old penchant for covering up when outdoors. Fear of the sun's harmful effects has gone so far that generations raised early this century and late in the last may suffer, in old age, from the effects of sunlight deficiency. Patterns of recreation have changed visibly in the last thirty years because of their fear. There has also been a technological response. Some improved sun-block creams are based on new synthetic compounds that mimic ultraviolet-absorbing agents occurring in organisms, including the coral *Acropora formosa*. SolarScan, an Australian device that vastly improves skin cancer detection, is due on the domestic market around the same time as this book (see page 66).

Australia's love of sport is conventionally put down to our sunny climate, which lures people outdoors. This explanation is not entirely consistent with recent sporting innovations. Melbourne's new Docklands stadium (currently known as Telstra Dome), which hosted its first football match in 2000 (a seventeen-goal hiding of Port Adelaide by Essendon), is the first oval to be fully roofed over, although much of the canopy can be opened. Race cam—pioneered by Channel Seven for the 1979 Bathurst 1000 car race—and its cousin stump cam—are encouragements to sport lovers to spectate in their lounge rooms. And the Super Sopper absorbent roller, invented by Gordon Withnall, enables sporting events to be played in wet weather. This machine comprises a hollow roller covered in absorbent foam. As it rolls across a rain-soaked pitch a smaller roller at the top presses the foam like a laundry wringer. The water dribbles into an internal trough mounted on the main axle and a hose at the end carries it away. Since 1974 this has saved much potentially lost time, especially in rainy territory such as Queensland.



One company, Primal Fishing, has in fact built its whole success story on innovation related to a love of outdoor life. Andrew Fogarty, an aquaculture biologist from Innisfail, Queensland, was also a keen fisherman (and already had experience designing lures) when the inspiration struck him to invent the "Prawnstar" lure. It is the first in a series of fish catchers developed by the company which attract fish by mimicking the natural movements of their usual prey, especially as it responds when under threat.

This result is achieved with design features, variable weights and the company's own "flickjigging" technique of lure manipulation. The Prawnstar simulates the appearance

Fishing lure inventor Andrew Fogarty lands a big barra with the Prawnstar flickjig lure.

and behaviour of prey with striking realism, and even mimics the sounds of wounded flicking bait. It has proved itself more effective than rival products and is now being distributed in Asia, South Africa, the South Pacific and Europe.

TOMORROW'S CHALLENGE

Australians have come up with many more world firsts than there is room to describe here. But while this book cannot be a comprehensive description of individual innovations, it is a trustworthy guide to the main areas where Australians make a big difference.

Some endeavours are notable for relative inactivity. Computers, for example: the public perception is that computer technology is going ahead in leaps and bounds, when in fact the basics are quite stable. Big changes observable in the market are due to suppliers gradually feeding out

increased capacity and modified applications, so that consumers constantly spend to upgrade. Australia's limited part in the advances that do occur is mostly in the area of software development. Biotechnology—creating lesser known products—has been many times more innovative here for decades.

Another popular and understandable misconception is that change and innovation are naturally speeding up as time goes on. In fact, as technologies become increasingly complicated, it takes more resources to step forward; more money and equipment, longer lead times. Revolutionary innovations like penicillin, the flotation process, the Sunshine Harvester and the modern merino sheep came when population was small, and facilities and spending were tiny compared with today's budgets.

In later decades such radical innovations have been rare in most countries, including Australia. But here the 1970s and 80s yielded such a multitude of lesser but still important breakthroughs that an impressive rate of progress was kept up.

The last ten years are too recent to be accurately assessed. But it is hard to discover in them the innovative intensity of earlier periods. To maintain their creative power in the twenty-first century, Australians may have to use lateral thinking—and turn to fresh challenges which offer more important gains than the well-worn targets of today's main efforts.