CHAPTER 4

ENERGY

AUSTRALIA was a child of the industrial revolution and the rapid conquest of the continent had demonstrated vividly the new forms of power and technology created by an industrial age. Visitors to Melbourne's centennial exhibition were amazed by a 'cosmos of exhibits' demonstrating many new forms of mechanical power. In the machinery hall, the inner sanctum of this 'Temple of Industry', hundreds of working exhibits turned silently in unison, powered by air pressure from a great steam-driven compressor. At night, more than one thousand incandescent bulbs—the world's largest electric light display—lit the galleries as brightly as daylight. Hydraulic lifts carried spectators up to a lookout beneath the dome, while an electric railway offered pleasure rides through the gardens outside. Technology, it seemed, had enabled people to overcome the limitations of their physical strength and the constraints of their environment. By 1888 most Australians lived in gaslit and coal-powered cities and towns, and railways had penetrated most settled parts of the continent.

Yet when people spoke of 'energy' they usually meant the personal strength or vitality of a man or woman rather than these new forms of mechanical power. 'There was a good deal of energy expended by us old pioneers,' an old-timer recalled. The progress of the country was often put down to the 'energy and enterprise' of its early settlers. Old-fashioned muscle power, horse power, wind power and water power still played important roles in the Australian energy system, and the outback farmer's toolshed contained a good deal of useful equipment not yet superseded by the gleaming new machinery on show at the exhibition.

MUSCLE POWER

During the pioneering days, while there was land to be cleared and ploughed, roads and railways to be built and mines to be sunk, the muscle power of strong men and women was constantly in demand. Throughout much of Australia a man was

still measured by how hard he could work, and in many places the length of the day was measured by the amount of work performed between daylight and dusk. Farmers, miners, timber-getters, builders, roadmenders, railway navvies, shearers, wharf labourers and many others still earned their keep by hard and unremitting physical toil. Feats of physical strength and endurance were celebrated in frontier communities, and those who performed them became popular heroes. Alf Broome, clearing his block of virgin bush near Bairnsdale, kept a daily log of his labours. On one day he recorded cutting three 7.6-metre (25-foot) box logs, on another he split 400 shingles, a few days later he stacked 2000 shingles. By keeping these daily tallies, the lonely pioneer registered his progress toward the goal of a completed homestead and farm. Yet the counts of hectares ploughed, sheep shorn, trees felled and bags of wheat lifted, which went down in the annals of local communities, are difficult to convert into a fair assessment of how hard Australians worked in 1888.

Each occupation, of course, established rough benchmarks for judging a person's fitness for the task and in a society that prized physical strength, success or failure in meeting the standard could strongly influence a man's self-esteem. Among wharf labourers, for instance, the minority of very strong men largely controlled the recruitment of labour on the docks. These men—the 'bulls', as they were called—were capable of lifting up to one hundred and forty kilograms or roughly twice their own weight. Even in lighter occupations it was considered important to be able to lift and carry a heavy load. When he engaged a 'diminutive boy' to work as a carter, the grocer Fred Cato thought it unusual enough to remark: 'He is 22 years of age and can't carry a bag of flour. I could do that when I was 14.' In the country, such a physical shortcoming would have been conspicuous and even more shameful.

From the measurements that scientists have made of the energy required for various kinds of work, it is possible to construct a rough table of occupations graded according to the severity of their labours. Considered in terms of an uninterrupted day's labour without mechanical assistance, some common late nineteenth-century occupations had the following approximate energy ratings:

The advance of steam-driven railways was accomplished only at the expense of vast quantities of manpower in shovelling rock, earth and ballast, cutting and laying sleepers and hammering spikes. Some gangs of navvies, like this one constructing the Homebush–Waratah line in New South Wales, also used small quantities of horsepower.
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Bookkeeper	(kilojoules a day)	10 000
Shoemaker		13 800
Butcher; stonemason		15 900
Firewood cutter		16 700
Agricultural labourer		18 000
Tree feller		18 900
Coal cutter; carrying sacks of flour		19 500
Coalminer (lying down)		20 000
Harvesting by hand		21 400

The heaviest kinds of work were concentrated in rural and mining occupations. The division between city and country was, in large part, a division between regions of moderately hard labour and incessant drudgery.

Many workers in the cities worked harder than their modern counterparts. Fewer than three in one hundred Australian men and women were able to sit down during their working hours. Most working men still walked to work, carrying their tools, often for five kilometres or more. In Melbourne only about one breadwinner in three could have travelled to work by public transport and in Sydney, a more compact city with a less extensive public transport system, the proportion might have been lower still. When he came home the working man's exertions were not over. There was probably firewood to be chopped, shopping to be carried home, a garden to be cultivated.

The tasks of the suburban housewife—cooking on a wood stove, beating rugs and carpets, washing clothes in a copper or tub, carrying water to the bath, cleaning saucepans, ironing clothes with a flat iron—called for a good deal of muscle power. Country women worked harder still. In the early days of the Riverina, when money was short and horse power scarce, women sometimes took the place of horses and pulled a harrow across the newly sown crops. On the Richmond River the wives of dairy farmers carried water from the river in buckets suspended from a wooden yoke across their shoulders, or walked inside an iron hoop that kept the buckets away from their skirts and relieved the strain on outstretched arms.

Where larger quantities of earth were to be excavated, as in the construction of the Coode canal at Fisherman's Bend in Victoria, the use of a steam navvy became practicable.
MELBOURNE HARBOUR TRUST

The spread of steam-powered, labour-saving technology scarcely touched remote areas. Although the pioneering phase of settlement had ended throughout much of southeastern Australia, new settlers continued to move into the forests of south Gippsland, northern New South Wales and Queensland, or the mallee scrub of South Australia and northern Victoria where the difficulties of clearing and cultivating the land were great. In the forests the initial work of felling, grubbing and burning was carried out almost entirely by unaided manpower. During September, October and November, the humid months when scrub-cutting was usually done, bands of men swung their two- to three-kilogram axes from daylight to dark. In the tropical rainforests north of Townsville the steamy climate and the thick scrub were reckoned to disqualify European workmen from the hard axe and hoe work of pioneering. 'I have been in northern Queensland for seventeen years, and nine years in Cairns', testified one settler.

> The climate is good, but I cannot do the same amount of work that I could do in the south, and the men I employ cannot. Even the horses cannot do the same amount of work.

It was fortunate, therefore, that indentured Melanesian labourers, whose constitutions were apparently stronger than those of white people and horses, were available to take their place. 'It seems to me', another settler remarked, 'that the hotter the weather the better the kanaka can work'. Toiling in the maize and cane fields from dawn to dusk and fed on a monotonous diet of cheap starchy food, the Melanesian labourers of north Queensland were surely the hardest-worked people in Australia in 1888.

Even in temperate climates and settled districts, agriculture remained an arduous occupation. Through much of the year bouts of heavy labour alternated with periods of lighter work. But twice in the farming year, during ploughing and harvesting, labour was prolonged and exhausting. 'Cultivation of the land', one old man admitted after a day in the field, 'is for young men following young horses'. Ploughing and harrowing, according to another, was

> absolute slavery ... Day after day on poor food and bad water you had to walk behind the ploughs and harrows, and following the harrows on rough-ploughed land had to be experienced before one can give an idea as to what it is like.

The rural division of labour was adjusted as far as possible to the age and strength of the labourer. The heaviest harvest work, such as scything, stooking, binding sheaves and loading bags of wheat, was reserved for fit, young men, and the lighter but still severe tasks of threshing and winnowing for youths and old men.

During the 1880s, the adoption of improved double-furrow ploughs, threshing machines and reapers and binders eased the physical strain and reduced the permanent labour force of farming. But the impact of new technology upon the labour force varied according to the local supply of labour, the size of the family farm and the muscle power of the family itself. Labour might have been more plentiful and traditional farming methods slower to die out in old goldfield areas, while in frontier areas such as the Wimmera, where farms were larger and labour was in shorter supply, mechanisation might have been further advanced. In 1883 Joseph Jenkins, an old farm labourer in the Ballarat district, noted that combined reapers and binders were becoming numerous, and over the next four years their numbers more than quadrupled. Yet in 1888 barely half the farmers who died in northern Victoria had any kind of harvesting equipment listed in the inventories of their estates and only one-fifth had reapers and binders. Even with reaping and winnowing machinery, harvesting a 260-hectare farm required the labour of a

Adventure Bay sawmill, Tasmania. The axeman wears moleskin trousers (here held up with a belt, as braces restricted the movement of the shoulders), bowyangs, a slouch felt hat, a flannel undershirt and cotton topshirt and a pair of strong boots, studded to prevent slipping. Axemen used a small whetstone to sharpen the edges of their blades, and lengths of strong string or copper wire to repair a split handle. Sometimes, as in this picture, a crosscut saw was used. Thus dressed and equipped, the best axemen could work for eight or ten hours a day through most kinds of weather.
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Kanaka sugar cane workers. In 1888 there were about 8000 Kanaka labourers in Queensland; fewer than 500 were women. Legislation of 1884 restricted the employment of the Pacific Islanders to the menial agricultural tasks of the sugar plantations, and excluded them from skilled and domestic work. White people thought Kanakas were better suited than white labourers to hard physical labour in a tropical climate.
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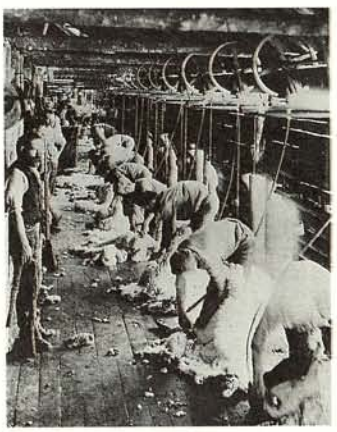
further 15 men to stack the bales of hay, and load, cart and stack the 108-kilogram bags of wheat. Rising at dawn and toiling far into the summer nights, the harvesters worked harder, though for a shorter season, than any other rural workers.

Technology had also begun to transform the other main form of seasonal rural labour—shearing. In 1888 a shed at Louth in New South Wales became the first to shear successfully with F.Y. Wolseley's shearing machine and in the course of the year eighteen other woolsheds were fitted with his equipment. Whether the machine eased the physical labour of shearing as well as improving its efficiency was a much-debated question. The fastest and most experienced blade shearers, who already averaged more than one hundred sheep a day, seem to have experienced little or no improvement in either the speed or ease of shearing. But among the less skilled and less experienced, the gains were greater. 'The slower and weaker men', a Riverina pastoralist observed,

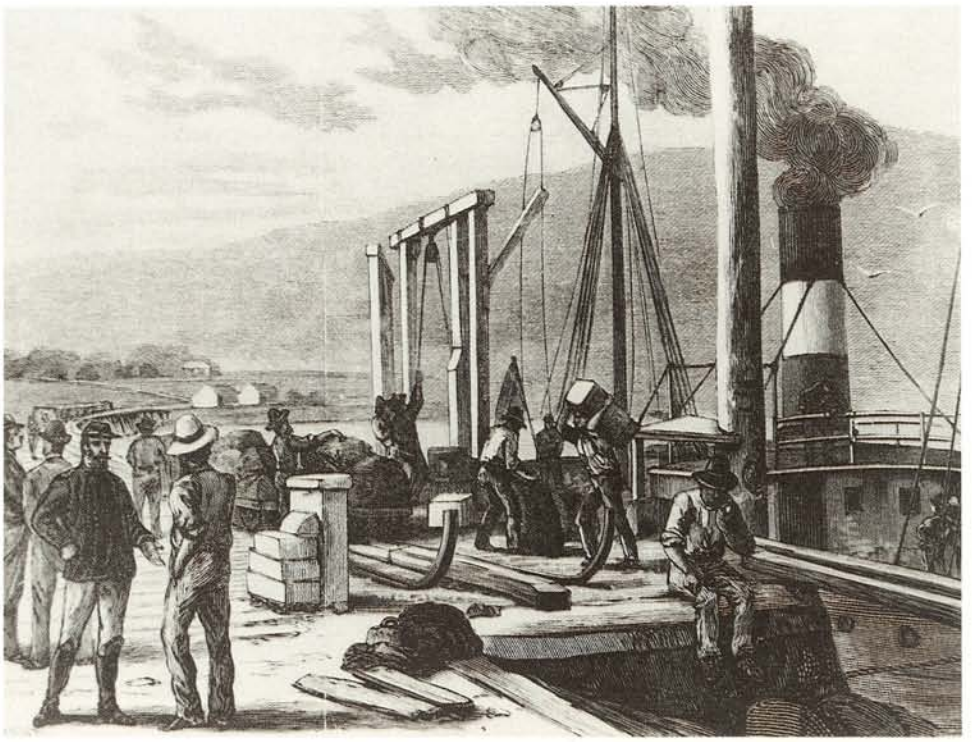
> are able to do more with the machine than they did before and, of course, they do it very much better. They are relieved of the laborious part of the work.

He estimated that tallies in the average shed improved from about seventy to one hundred sheep a day. From the pastoralist's point of view, the machine was attractive in opening up the possibility of employing unskilled and possibly non-unionised labour. Wolseley himself made no bones about this. 'The greatest benefit it confers', he claimed, 'is that it makes the employer to a great extent independent of skilled labour'. The benefits for the shearer himself were not as great, for the machine eased the strain on his wrist but not the greater pressure upon his back.

Judged by the energy they consumed, miners were not as hard-worked as some rural workers, such as harvesters. Yet the dark, cramped and dangerous conditions under which they laboured made their job even less enviable. In 1888 compressed air drills were used by fewer than one-quarter of the deep quartz goldminers of Bendigo and Ballarat. As with the shearing machine, mechanisation served to



Machine shearing. Yamma shed, Morundah, New South Wales, in full swing, 1888.
A.S. O'KEEFE



By 1888 even minor ports such as Bulli in New South Wales were served by small steam-powered vessels, although the handling of baggage and general cargoes remained a task for strong men with ropes and pulleys.
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increase the output of the worker rather than to ease his labours. Standing for eight or ten hours a day behind a chattering pneumatic drill with clouds of fine dust permeating the air and seeping into the miner's lungs was tiring and dangerous.

Coalmining remained almost completely unmechanised. A miner generally hewed and loaded about three tonnes in an eight-hour day. Yet in times of peak demand he could be required to work underground for fifteen or even twenty hours. In one exceptional case, a man who had already worked fifteen or sixteen hours at the face was instructed by the manager to 'go home and get a little tucker' and return as quickly as possible to the pit in order to begin another eight or nine hours' work. The unevenness of the miners' working hours was caused by the fluctuations in demand for coal at the port and the unwillingness of mine proprietors to shoulder the costs of stockpiling and double-handling coal. A Newcastle miner remarked:

> A steamer comes, and a quantity of coal is required to load that steamer. The mine may have been idle, but a steamer comes into a jetty, and the quantity of coal that is standing in the waggons is placed on board the steamer; then it is a question of getting the men to work, and keeping them there until that steamer has received the whole of her cargo or the quantity she came for. The men are, practically, the rolling stock.

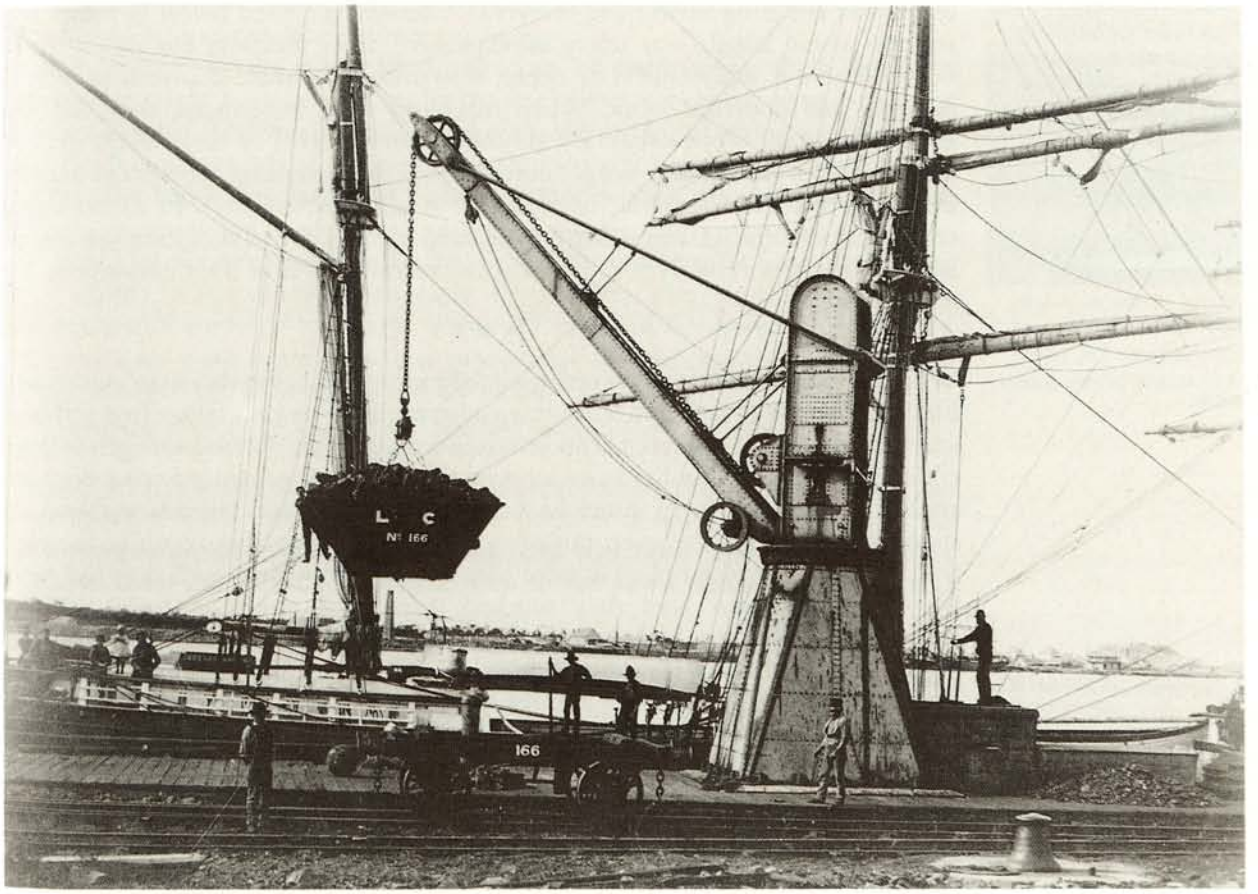
One unionist believed that coalminers 'took a good deal more out of themselves in this country than ... in the old country' and cited the fact that, while British miners always wore a shirt, the Australians worked naked above the waist. But another conceded that in the comparatively thick New South Wales coal seams miners did not have to adopt the cramped and tiring posture of miners in many British pits.

During 1888 the handling of coal and other heavy cargoes in the ports of Newcastle, Sydney and Melbourne was being rapidly changed by the introduction

of large steam and hydraulic cranes. Eleven hydraulic cranes were installed at Bullock Island in Newcastle harbour and seven similar steam-driven cranes were in operation in Sydney. Most modern vessels had their own steam-driven winches. When Alexander Sutherland inspected the Melbourne waterfront in 1888 he noted 'the smoke of puffing and rattling donkey engines and the dust of collier vessels unloading with a mighty din'. One old stevedore contrasted the old and new methods of cargo handling:

> Well, we discharged in bags worked over a barrel, and had to heave them out of the hold by this barrel, to which there were a couple of handles or arms. We had no winch or portable windlass, but just the same sort of appliance as you see at a new diggings.
>
> *That sort of thing employed vastly more labour than we do at present?* Yes; we used to have four men in the hold, one at the whip to steady the bags, and two at the wharf.
>
> *When you came to lift heavy cargo, were there not, as a rule, eight men at the hoist?* Yes.
>
> *You had eight men to hoist what one man does today?* Yes.

As cargo handling was mechanised, the files of coal lumpers bearing their heavy baskets from ship to shore began to shorten. Within this diminishing dockside labour force, however, competition for work became fiercer and rates of pay declined while the docker's work became, if possible, even more severe. 'It is driving work', one lumper remarked. 'If you don't go as hard as ever you can, you don't get a job at all. You *have* to go as hard as ever you possibly can.'



Mechanical power, in the form of hydraulic cranes, was first introduced to handle heavy, bulky cargoes, such as Newcastle coal. But the low cost and the weight of such commodities meant that they were carried by sailing ships rather than by the speedier but more expensive steamships.
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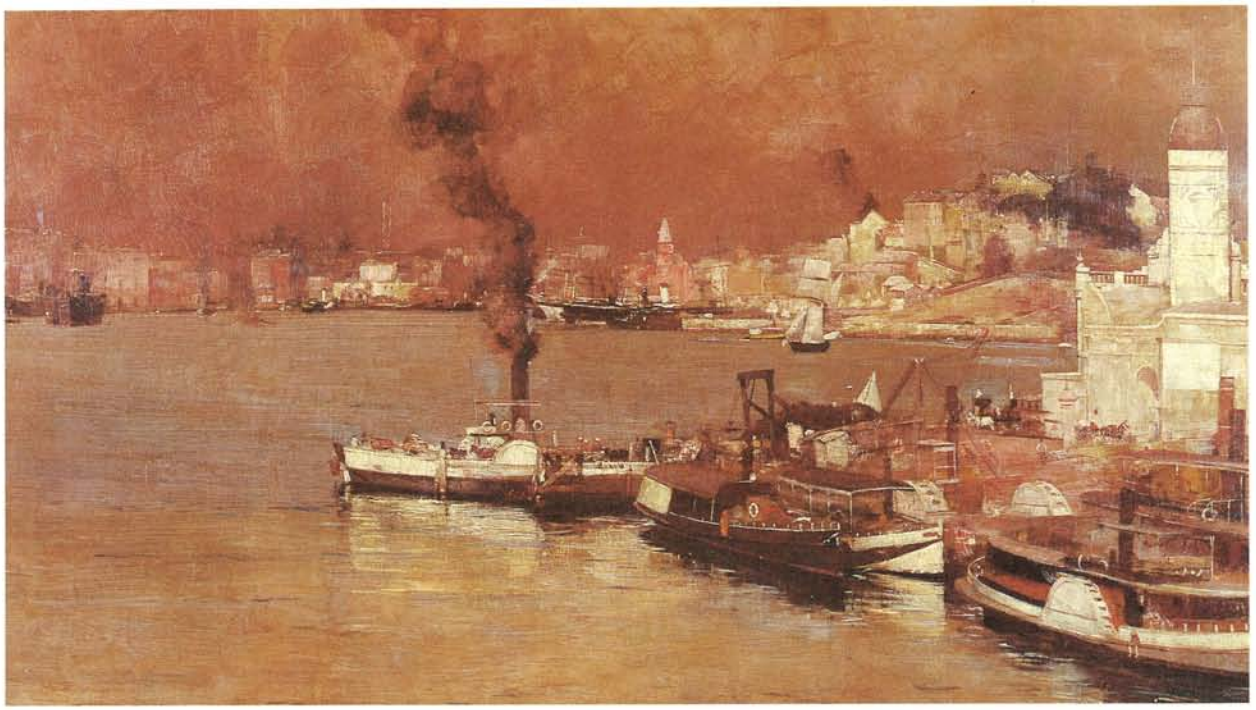

An autumn morning, Milson's Point, Sydney, *by Tom Roberts. This murky study, painted during the artist's visit to Sydney early in 1888, reminded an* Age *reviewer that 'this is a city consuming fossil fuel and not charcoal'. The smudgy skylines of contemporary photographs also often show the pollution created by a growing number of factories, locomotives, steamships and household fires. Oil, 1888.*
ART GALLERY OF NEW SOUTH WALES

The proportion of the workforce engaged in heavy physical work was declining, but it was declining slowly and unevenly. Changes occurred fastest in trades and regions where labour was scarce or expensive, as in shearing, but much more slowly where it was plentiful or cheap, as in unskilled female occupations such as tailoring and domestic work. When machines were introduced, they did not necessarily make work easier. By abolishing some forms of hard work, such as threshing or scything, they simply concentrated the remaining workers in equally laborious tasks, like building haystacks or loading wheat bags. In short, when employers introduced steam-powered machinery they aimed at cutting the cost of labour but not necessarily at improving the working lives of their employees.

FOOD

Working men and their wives recognised the close link between a man's work and his diet. The strong tradition at working-class tables of serving father first and best was therefore based upon the economic importance of his physical strength to their common survival. How hard and long people laboured influenced what they ate and when they ate it. In Australia the large appetites and legendary thirsts of shearers and miners were inseparable from their prodigious labours; it is no wonder that in outback areas employers were judged as much by how well they fed their workers as by how hard they worked them. The transition from a high-carbohydrate diet to a high-protein diet is connected, in a broad way, with the decline of physical toil. One sign that the physical demands of work might have been declining towards the end of the nineteenth century is the gradual substitution of the evening for the noonday dinner. A domestic economist advised her working-class readers:

> You will want a good, nourishing, wholesome and tasty breakfast, a light but yet sustaining luncheon, and a hearty, jolly dinner when your husband comes home in the evening, having done his work for the day.

Nevertheless she conceded that 'if he prefers dinner in the middle of the day he must have it'.

Australians were among the world's biggest eaters. It does not follow, though, that they were also among the world's hardest workers. In an intriguing statistical exercise, Timothy Coghlan compared the diet of the average Australian with some of his or her European and American counterparts. He found that the energy yielded by the meat- and cereal-rich Australian diet was greater than the British, French, German or American. And since proportionately fewer Australian women and children worked and the men themselves worked shorter hours, Coghlan concluded that Australians, unlike other people, had a good deal of surplus energy to burn. As working hours became shorter and more standardised during the 1880s, there was also an upsurge in leisure activities, and especially of those vigorous sports such as football, rowing and athletics that were best for burning off the surplus energy of the young.

Coghlan's averages concealed a good deal of variation in the diets of Australians. In the days before railways and refrigeration, people's eating habits varied markedly from season to season and from place to place. Tasmanians, for example, ate three times as much mutton as beef, while Queenslanders ate three times as much beef as mutton. In remote rural areas, settlers had to eat mainly what they could grow for themselves. William Stagg and his family killed their own pigs and the occasional rabbit or quail for meat, milked their own cows and grew their own cabbages and tomatoes. In bad times, such as the drought years of the late 1880s, when the cows ran dry and many vegetables failed to come up, they nearly starved. The driest and most remote areas depended almost entirely upon food imports, and since the drought had denuded the country even of feed for transport animals, the price of human foodstuffs rose accordingly.

Fishermen on the Gippsland Lakes, Victoria.
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In the cities, on the other hand, the costs of transporting food from the countryside might have been offset by the size of the market for produce. Part of the food supply for Melbourne and Sydney was still produced within the bounds of the cities themselves. Many suburban householders cultivated their own vegetable gardens and had room for some fruit trees. But as their populations grew and outlying orchards and market gardens were converted into suburban real estate, the cities looked increasingly to the countryside to supply their food. Production of perishable food, including such staple items as meat, fish, vegetables and milk, was necessarily confined to an area within the range of fast transport to the city. Since railways were more than four times faster than horses, their construction greatly enlarged the food supplies of the cities.

Melbourne now drew its fruit and vegetable supplies across the Dividing Range from the Goulburn valley as well as from the older-established market gardens along the Yarra valley and in the sand-soil areas south of the city. Each day, fast trains brought fresh milk directly from the pastures of south Gippsland. By 1888 the once-prolific fisheries of Port Phillip Bay had been largely destroyed by pollution from the Yarra. 'For the past four or five years', testified one fisherman to a select committee on the fishing industry,

> the fish is getting scarcer and scarcer, till there is none to be had now, and that is through the silt, it has spread all over from Mordialloc to the Werribee, close on 30 miles, and it is all over the Bay.

But Melbourne's fish eaters were rescued by the railway: two-thirds of the city's supply was now conveyed in ice-packed trucks from Westernport and the Gippsland Lakes.

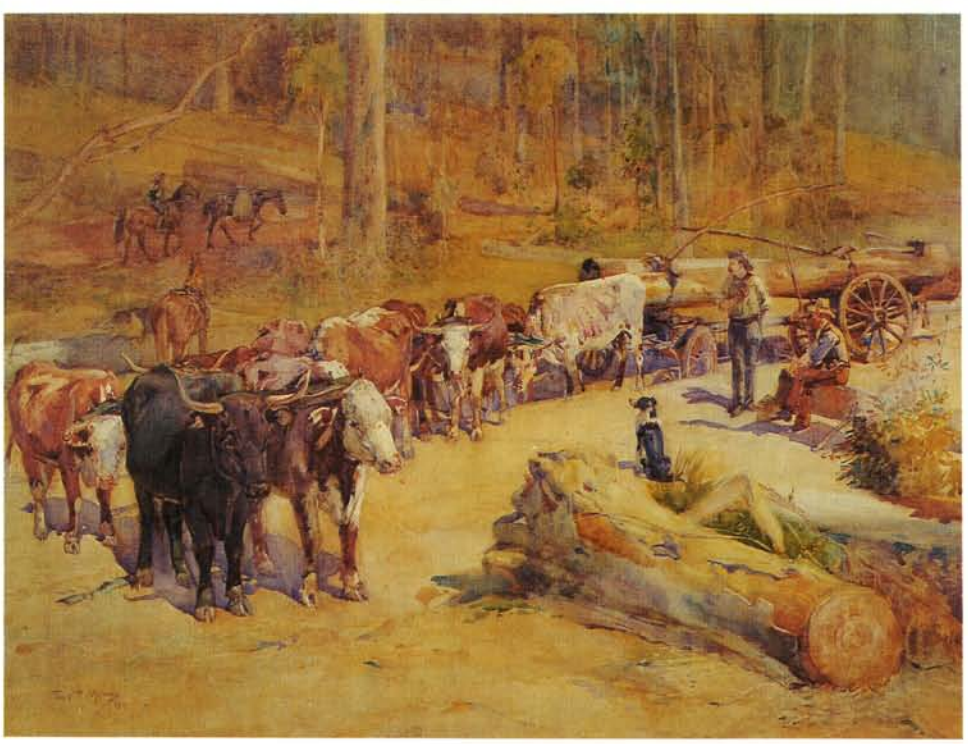
Most of Sydney's and Melbourne's fresh meat was still killed at Glebe Island and

West Melbourne abattoirs, but stockmen, butchers and sanitary inspectors had begun to preach the advantages of country killing. Livestock that had been driven overland or transported to the city in crowded railway trucks lost condition on the journey; but with refrigerated vans it would soon be possible to kill the fattened beasts up-country and deliver the chilled carcases to market in a matter of hours. Soon, it seemed, the railway enthusiast's vision of a city fed by speedy railways from far-flung gardens, orchards, pastures and fisheries would be a reality.

ANIMAL POWER

When nineteenth-century working men described their labours, they often compared themselves to working animals. 'It is just the same with a horse', a stevedore remarked in explaining how a wharf labourer should be managed. 'You cannot go on working him forever without a spell.' Many of the expressions they used about working life derived from the techniques of horse handling. A man resuming work was 'back in harness'; a boss carefully controlling his men kept 'a tight rein'; a foreman asked his men to put their 'shoulders to the wheel'. In 1888 Australia's 1.3 million horses contributed more energy than either men or steam-driven machines, and possibly as much as the two combined. An unspecified number of bullocks, camels, mules and even goats were also used for traction.

Bullocks were better than horses for pioneering. They were better at the hard, steady work of clearing and ploughing rough ground and, because they were less temperamental than horses, they did not rear and injure themselves on exposed roots or brambles. They were better at hauling heavy loads over uneven ground or up steep inclines. And, most importantly, they were cheaper to buy and maintain, since they could forage for themselves and did not require shoeing or expensive harness. The trouble with bullocks was that they were very slow. Even on a good road, a team of bullocks covered only fifteen to twenty kilometres a



The bullock team, *by Frank Mahony. Watercolour, 1891.*
ART GALLERY OF NEW SOUTH WALES

Horse power, northern Victoria. Just as the introduction of machinery did not immediately free men from heavy labour, so horses were still required on farms to perform the traditional tasks, and to power some of the new machinery.
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day, while a team of horses covered two or three times, and a train about fifteen times that distance.

As the pioneering phase of settlement came to an end and good roads and railways were built throughout the colonies, bullock power was confined to rough and remote country. In the forests of south Gippsland, north Queensland and southwestern Australia, they remained important, but elsewhere they were a dying breed. Along the northern New South Wales coast, bullocks that had powered the cane-crushing plants of sugar mills made way for steam engines. As the rail pushed westward into the outback, the teams moved ahead of it, and by 1888 their operations were centred on the railhead at Bourke whence a network of tracks radiated north, west and south into the most sparsely settled pastoral districts. The further the rail advanced and the larger became the outback wool clip, the longer were the bullock teams and the more intense the competition between them. These bovine juggernauts often comprised as many as thirty-two bullocks and pulled up to sixteen tonnes. In flat open country with fair roads, such as the area around Hay in the Riverina, the hauling capacity of bullocks barely made up for their slowness and the faster horse teams were able to compete successfully with them. Further west and in the far north of South Australia they faced vigorous competition from the climatically better-adapted camels. In the dry winter of 1888, when the Darling was closed to steamers, the residents of Bourke and Wilcannia were surprised and amused by the arrival of several camel trains, bringing woolpacks and shearing supplies to the stations of the far West.

As bullock power retreated before the advance of the horse and camel, so did horse power retreat before the all-conquering steam engine. Yet, while railways were faster and more economical than horses, and steam engines were more powerful than a horse treadmill, the mobility and versatility of horse power gave it an advantage over many other forms of power. Pastoral stations, of course, had large stables of saddle horses for mustering and droving. In rugged and mountainous country, such as northwest Tasmania, south Gippsland and the Australian Alps, packhorses were used. Over eight hundred horse-driven whims and puddling machines still operated on the Victorian goldfields. In the New South Wales coalmines, pit ponies remained the principal means of underground

transport. In agriculture, horses were used extensively to power threshing machines and chaffcutters as well as to pull ploughs, harvesters and other farm equipment. New inventions, such as cream separators and chaffcutters, were advertised as being compatible with either horse or steam power.

The biggest users of horse power were probably the country's cereal farmers. A large South Australian wheat farm, with almost 260 hectares under crop, would have maintained twenty heavy draught horses, ten saddle or light horses, a buggy team and four teams of working bullocks. A map of Australia's horse population would show the largest concentration through the wheat belts of South Australia and Victoria and in the remote western districts of New South Wales and Queensland, beyond the reach of rail.

A horse, considered as a source of energy, was largely what it ate. Experienced horse-handlers recommended a balanced diet of hay, oats, bran and other forage plants, but the average farmer was loath to purchase feed and usually gave his horses whatever was at hand. In hard times, poor farmers often resorted to straw and inferior grasses. 'We give our horses straw mixed with hay', remarked William Stagg during the drought. 'It is not good feed but it is more than some has for they give their horses straw alone.' Poor feed naturally affected the horse's performance. Thomas Dobeson, who earned a precarious livelihood as a carter, grazed his horse on wasteland near his home at Botany; but after a full day's work the horse, 'being grass-fed', was usually too 'knocked-up' to begin another and had to be spelled for several days.

Melbourne and Sydney each stabled about 20 000 horses. Australian capital cities offered plenty of vacant land on which horses could forage and their wider carriageways might have postponed the problems of congestion that had already afflicted London and Paris by 1850. Not until the early 1880s did the crowding of horse-drawn cabs and omnibuses in central Melbourne become an urgent public question. Although horse-drawn public transport declined during the 1880s, horse-drawn private transport continued to grow. Horses remained the principal means of transport in the cities. They carried cargoes from ports to warehouses and from warehouses to retail shops. They pulled delivery vans, milk floats, fire engines and hearses. They carried materials to city building sites and provided the power to hoist into place girders, window frames and other components. Each morning they hauled wagons loaded with fresh food and fodder from the city's hinterland and at night they hauled drays loaded with nightsoil from the city's back lanes to its rural fringe.

As Melbourne expanded, the costs of maintaining the horse transport system increased. Vacant allotments were built on, and horse owners became more reliant on fodder imported from the countryside. A working horse consumes approximately fourteen kilograms of fodder a day or about five tonnes a year. In the late 1880s, therefore, the horse population annually consumed about 100 000 tonnes of horsefodder. (After making its way through the horse's alimentary system, most of this was deposited on the city's streets.) Of all primary fuels, horse fodder was the most sensitive to transport costs, so as the city grew, the immediate hinterland was progressively given over to the cultivation of fodder. Between 1871 and 1900 the proportion of agricultural land within the County of Bourke devoted to the cultivation of oats and hay grew from 36 to 64 per cent. Already at the end of the 1870s the annual feed bill for each horse maintained by the Melbourne Omnibus Company exceeded the original cost of the horse, and the company's bill for feeding horses was larger than its bill for paying men. The cost of horse fodder in the Melbourne market continued to increase, as did the difference between the metropolitan and provincial (Ballarat) price. It is possible that the late nineteenth-

century revolution in urban transport was not only induced by the improving technology of steam, but forced upon Australian city dwellers by the increasing direct—and social—costs of horse transport.

FIREWOOD

In most parts of Australia in 1888, including all but one of the capital cities (Sydney), wood remained the main domestic fuel. All but a few housewives cooked over a wood stove, washed the family's clothes in a wood-stoked boiler or copper, heated the weekly bath water in a chip heater and warmed the house in winter by a wood fire.

Firewood was also Australia's main industrial fuel. The steamers that plied the Murray and Darling rivers and transported the outback wool clip to market consumed large amounts of firewood. The steam engines that powered the pumps, compressors, winding gear and batteries of Victoria's goldmines and that alone accounted for almost half of the colony's industrial steam power, used firewood almost exclusively. So did the engines driving farm equipment such as chaffcutters, threshing machines, grain crushers, sheep-shearing machines, pumps and cream separators, and many of those installed in bark mills, saw mills and flour mills. Even some urban-based manufacturing industries such as brickmaking would have used wood fuel.

Until the 1880s the wood-based fuel system was necessarily a local one. Of the 6s 6d paid for a load of firewood at Walmer in central Victoria in 1879, 5s was attributable to the cost of carting it from Ravenswood just 21 kilometres away. Wherever roads were poor or the terrain difficult, the price of firewood rose steeply. At Mount Lyell on Tasmania's rugged west coast, the cost of carting firewood to the boiler house of an early mine was almost prohibitive, even though dense forest lay only a stone's throw away. Timber-getters, therefore, especially in the neighbourhood of towns and mines, moved gradually along the main roads, keeping to the higher ground from which logs could be most easily retrieved and selecting the thickest and straightest trees first. In the Wombat and Bullarook

Timbergetting. Horses took on heavy tasks in the forests. This team is hauling logs in Western Australia.
ANU ARCHIVES OF BUSINESS AND LABOUR

Tom Roberts, The woodsplitters. *Oil, c1886.*
BALLARAT FINE ART GALLERY

forests east of Ballarat the demand for mining timber and boiler fuel was so great that, as the nearer stands became exhausted, timber-getters extended their reach by a network of timber tramways. By 1888 a once densely forested area of 280 000 hectares extending some sixty kilometres from Creswick to Woodend had been cut back to barely one-seventh of its original size. The mine proprietors of Ballarat and Bendigo imported timber from places 160 kilometres away and agitated for the construction of a railway to exploit the timber resources of the Otway Ranges some hundred kilometres to the south. Many of the timber-getting syndicates that had plundered and exhausted the Wombat Forest in the 1870s and 1880s moved on to the Otways or the Warburton area around the end of the decade.

In South Australia the copper mines at Wallaroo and Moonta had exhausted local supplies of fuel and were paying 6s a tonne to transport it 160 kilometres from the Flinders Ranges. Along the Darling River the New South Wales conservator of forests observed that the country was 'being gradually denuded of what little timber it possesses and there is no new growth worth mentioning to provide in the future for an ever increasing demand'. Fuel for household purposes was unprocurable within eight kilometres of Wilcannia and around Cobar—where a copper mining company paid £24 000 a year for firewood—it was extremely scarce. The supply of timber for the sugar mills of Bundaberg was exhausted, and proprietors were turning to the newly opened Howard coalfields.

In the cities and towns, a fuel crisis was probably averted only because railways had brought new timber reserves within economic reach. Adelaide's firewood, once gathered mainly along the northwestern line near Hamley Bridge, was increasingly gathered from the Mallee country east of Eudunda. Small quantities were shipped to Sydney from as far afield as the northern rivers, the southern ports and Victoria. The Newcastle coalminers' strike, which for some weeks reduced Melbourne's coal supplies to a trickle, made people more than ever aware of their continuing dependence on firewood. 'In ordinary times', an *Argus* reporter discovered,

> the conveyance of firewood to Melbourne and other large centres of population involves the use of about 410 [railway] trucks per day, and as these trucks will carry an average of six tons, the daily consumption of railway-carried firewood may be roughly set down at something like 2500 tons per diem. The North-eastern district is by far the largest contributor of firewood, supplying fully one-fourth of the total requirements of the colony; but every railway line in the timber districts furnishes its quota, including Gippsland, Lilydale, Daylesford, Bacchus Marsh, Macedon and Lancefield. Geelong, Ballarat, Sandhurst, Maryborough, & c. are supplied from their respective districts, their aggregate consumption amounting to about 1000 tons per day. A few years ago firewood for Melbourne was not brought from beyond a distance of 50 miles, but as supplies within comparatively easy reach of Melbourne became exhausted, the radius was extended, and the price of carriage reduced.

Melbourne, it appears, was consuming between 350 000 to 450 000 tonnes of rail-carried firewood per annum, or between three-quarters of a tonne and one tonne per person, a figure consistent with the more comprehensive figures for South Australia where the railways carried just over 70 000 tonnes of firewood. By lowering cartage rates for firewood and opening up untapped forest reserves, coal-fuelled railways had helped to perpetuate the wood-based energy system. People were nevertheless apprehensive about the future supply of firewood for the larger towns and cities. A leading Melbourne firewood merchant predicted that supplies of box, 'incomparably the best wood for heating purposes', would be exhausted within ten years.

COAL POWER

The map of Australia in 1888 may be divided roughly into three broad energy regions. The first, in which coal was the principal source of heat, light and power, was confined to the closely settled parts of New South Wales within the radius of about 160 kilometres of Sydney, together with perhaps one or two small pockets of country on the coasts of southern Queensland and eastern Tasmania. The second, in which coal was used as a locomotive fuel and for gas lighting (though not for domestic heating) took in the other capital cities, the largest railway towns and a number of smaller ports. The third, where fodder and firewood remained the main fuels and kerosene the main illuminant, comprised virtually all the rest of rural Australia, including most country towns.

This pattern is explained mainly by the geographical distribution of Australia's workable coal deposits. Of the 2.5 million tonnes of coal raised in Australia in 1888, 1.5 million tonnes came from a single field, the Hunter valley of New South Wales. Surveying the potential of the Hunter valley field, the geologist T.W. Edgeworth David estimated in 1888 that, at the current rate of exploitation, the Upper or Newcastle measures would remain in production for a further 200 years. There remained, still largely unexploited, the Middle or East Maitland measures with a potential production of 20 000 tonnes a day for 100 years and the newly proven Lower or Greta measures with a potential of 40 000 tonnes daily for 200 years.

The second main New South Wales field—the Southern or Illawarra coalfield—had only one-third the production of the Hunter valley, but as the best source of high-quality steaming coal it expanded rapidly during the 1880s when six new collieries were opened at Mount Kembla (1883), Helensburgh (1885), North Illawarra (1887, 1889), South Bulli (1887) and Bellambi (1888). Two further fields were the Western or Lithgow fields—the largest suppliers of coal to the New South Wales Railways—and the newly developed coalfields at Ipswich and Wide

Bay in Queensland. The two smallest fields—the Nicholas colliery near Fingal on the east coast of Tasmania and the south Gippsland coalfields in Victoria—were of strictly local importance. Of the Australian colonies, Queensland and New South Wales were practically self-sufficient in coal; Tasmania mined about as much as it imported; while Victoria, South Australia and Western Australia imported almost all their coal from New South Wales.

Coal consumption in eastern Australia decreased with the distance from Newcastle or Port Kembla to the point of use. Although the energy/weight ratio of coal compared favourably with that of alternative fuels—a kilogram of coal generates about twice the heat of a kilogram of firewood—the cost of transport would quickly reduce its advantage. A tonne of coal at the pit at Newcastle cost 7s; after transport to Sydney the price had risen to 21s; in Melbourne it cost 24s to 30s and by the time it got to Bendigo it was 50s. The frontiers of the coal-based energy system were essentially those of cheap transport, which in 1888 meant coastal ports and their nearer hinterlands.

The chairman of the Metropolitan Gas Company of Melbourne claimed that gas consumption had 'about doubled' in the five years between 1883 and 1888. The company's policy was to extend the network well ahead of demand and promote the sale and hire of gas stoves.
LA TROBE LIBRARY

In the decade before 1888, Australia's domestic coal consumption increased three times as fast as its population growth. As railways expanded and freight rates declined, the coal-based energy system extended its frontiers. Of about fifty towns in New South Wales and Victoria with their own gasworks, all except one or two coastal ports or nearby towns (Bega, for example) were either directly connected by rail to the coalfields or had substantial urban populations (6000 or more) and were connected by rail to a major port.

From the late 1870s, when the number of steamers entering Australian ports first exceeded the number of sailing vessels, the demand for bunkering coal increased steadily. By 1888, steam was the standard form of maritime transport, not only for passengers and mail but for all except the heaviest and bulkiest cargoes. The average size of steam vessels entering the port of Melbourne had almost doubled over the previous decade and the volume of steam-carried cargoes had risen to about three times that carried by sail. Even the smaller outlying ports along the Queensland and northern New South Wales coasts were served by steamers.

Railways were second only to steamships as major coal consumers; Victoria, the colony with the busiest rail system, burned almost half its annual coal imports in railway locomotives. Since almost every tonne had to be shipped from Newcastle, unloaded and reloaded in Melbourne and hauled by rail to depots throughout the colony, fuel was a costly factor in Victorian railways management. By contrast, New South Wales seemed almost geographically predestined for the steam age, since each of its main railways traversed a major coalfield—the northern line through Newcastle, the western line through Lithgow and the southern lines through Mittagong and Illawarra. In 1888 the Victorian and New South Wales railways each consumed about 225 000 tonnes of coal, but the fuel bill of the Victorian system, according to the chief commissioner of railways, was about four times that of the New South Wales Railways. It is no wonder that so much interest was shown during the late 1880s in the prospects of the South Gippsland coalfields. But the local coal deposits were thin and damp and by the time Victorian coal had been hewn, raised, dried out and transported thirty kilometres or so to the railhead at Warragul, it was more expensive than coal transported more than 1300 kilometres from Newcastle.

The third most important coal consumers were probably the private and municipal gasworks which lit, and increasingly heated and powered, Australia's cities and towns. The Australian Gas Light Company—which supplied most of Sydney—used about 150 000 tonnes. Together with the coal used by thirty other non-metropolitan gas companies in New South Wales, the total cannot have fallen

very much short of the railways' annual consumption. The metropolitan companies in particular had greatly augmented their production and distribution systems during the 1880s and were vigorously promoting gas, not only as an illuminant, but as a fuel for cooking, heating water and for small industrial engines. In Melbourne about one in four households cooked with gas and about one-third of gas was consumed during daylight hours.

The use of coal as an industrial fuel was largely confined to the coastal cities. Yet with the exception of a few heavy industries such as boiler-making, brick-making and brewing, the amount of steam power used by most urban-based industries was quite small—compared at least with such power-hungry non-urban industries as mining, timber-milling and flour-milling. The central problem of urban energy use in the 1880s was to combine the economies of large-scale power *production* with a predominantly small-scale and highly diffused pattern of power *use*. The most efficient way to produce motive power from coal was by means of a large coal-burning steam engine; yet the typical applications of motive power in Australian cities—in such devices as sewing machines, printing presses, sausage machines, mechanised bakeries, tramcars, passenger lifts—required only limited horsepower. The costs of providing each of these devices with its own steam engine could almost outweigh the benefits, given the difficulties of carting and storing coal, the need to employ a stoker, the dead time spent in getting up steam before work could begin and the problem of disposing of ash and smoke. The solution to urban power needs called for the centralised combustion or conversion of coal into a form of energy that could then be cheaply distributed throughout the city and used intermittently by a multitude of small power users.

Hydraulic lift.
Manufacturer, *Melbourne, 15 Nov 1887.*

A simple method was to transmit power from a central steam engine by a mechanical system of belts or cables. The winding apparatus of a mine or the constantly running cables of Melbourne's tramway system were important examples. But the friction and waste inherent in mechanical transmission limited it to simple linear applications. A second method was to convert the mechanical power of the central steam engine by means of a compressor or pump into air or water pressure which, in turn, was transmitted by means of hoses or pipes to the point of use. The working exhibits at the Centennial Exhibition were driven by air pressure from a large steam-powered compressor. In 1887 a Melbourne company erected a steam-driven pumping station on the Yarra near the Australian wharf and laid some eleven kilometres of high-pressure water mains throughout the city. The hydraulic passenger lift, drawing its power from such underground water mains, was necessary for the development of the seven-and eight-storey office buildings that began to appear along Collins Street and Pitt Street. Advocates of hydraulic power anticipated a range of novel uses, including working cranes on wharves and city building sites, driving industrial machinery and generating electric power. The prospectus of a Sydney hydraulic power company concluded:

> ... the advantages offered to the general public are very large because power of the most simple application can be had from the mains direct to perform any mechanical work, from the driving of a sewing machine to the working of the most powerful machinery known to modern science.

'A long-felt want': could electric power help women steer their trailing garments?
Melbourne Punch, *13 Sept 1888.*

Coal power could also be distributed under pressure by means of coal gas. Half the industrial engines in the city of Melbourne, where printing, clothing and other small-scale industries were concentrated, were powered by gas. The seven-horsepower Otto gas engine exhibited at the Centennial Exhibition was a popular make. While the small gas engine was more expensive to run throughout an eight-hour day than its steam equivalent, experts agreed that

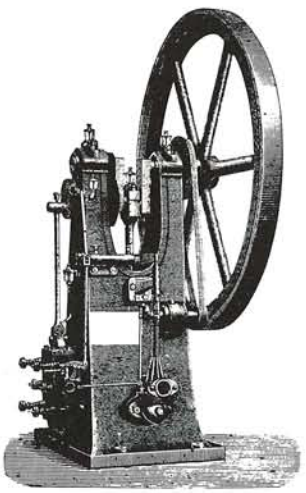
> for intermittent work the gas engine is much more economical . . . and this fact, together with its safety, cleanliness and convenience, makes the gas engine very desirable where small powers are used.

Similar advantages could be claimed for the petrol-driven internal combustion engine, an early version of which was also exhibited at the Melbourne exhibition. 'Its value', one observer noted, 'will be recognized in places where, as so often is the case in the colonies, gas is not procurable'. In New South Wales, Lawrence Hargrave was experimenting with engines powered by petrol and compressed air; at the annual meeting of the Royal Society of NSW in May 1888, he exhibited a compressed air engine for driving a flying machine.

The glamour fuel of 1888 was electricity. In the eyes of promoters its potential was almost unlimited. The president of the Victorian railways electrical society predicted:

> Electricity and electrical appliances are making such jumps that, before many years have passed, numbers of works now done by means of other forces will be done by electrical means. Before many years have elapsed there will not be a large building in which electricity is not used for lighting and driving machinery. The street tramways will all be electrical. Electric lights will illuminate the streets, and, in many ways now not attempted or thought of, electricity will be employed.

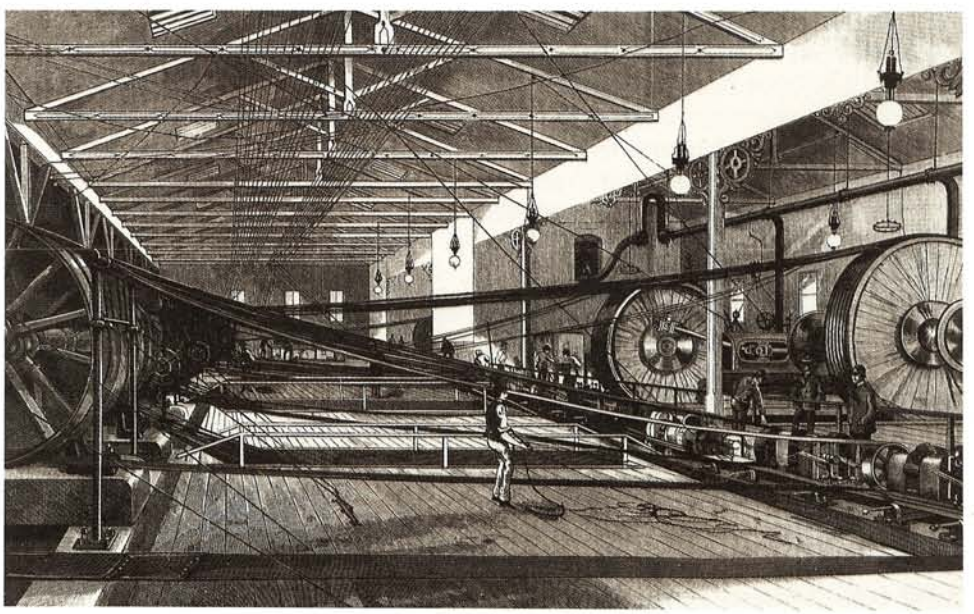
Gas engine imported from Germany. Australasian Ironmonger, *1 Apr 1888.*



Reports constantly appeared of exciting new electrical devices such as burglar detectors, surgical cauterisers, curling tongs, sewage treatment plants and apparatus for executing criminals. Mr E. Pritchard of Sydney gave demonstrations of a battery-driven tramcar and Mrs Alice Cornwell of Melbourne launched a company to promote the use of 'an electric light which can be bought by the pint, just as kerosene oil can be bought'.

Most of the technical and economic problems that had plagued the pioneers of electric light had now been solved. A large steam-powered dynamo could generate enough current to light several large buildings almost as cheaply as the dimmer and less healthy gaslight. In Melbourne and Sydney a dozen new public companies

An electric lighting plant at the Melbourne Centennial Exhibition. It took a 1500-horsepower steam engine, two huge Brush dynamos and 950 incandescent lamps to illuminate the galleries of the exhibition. Electricity was three times as expensive as gaslight, and the lamps often grew dim as evening sessions advanced. But the organisers were captivated by the novelty of electricity and its 'magical property of injecting life into lifeless pictures'. Australasian Sketcher, *6 Sept 1888.*

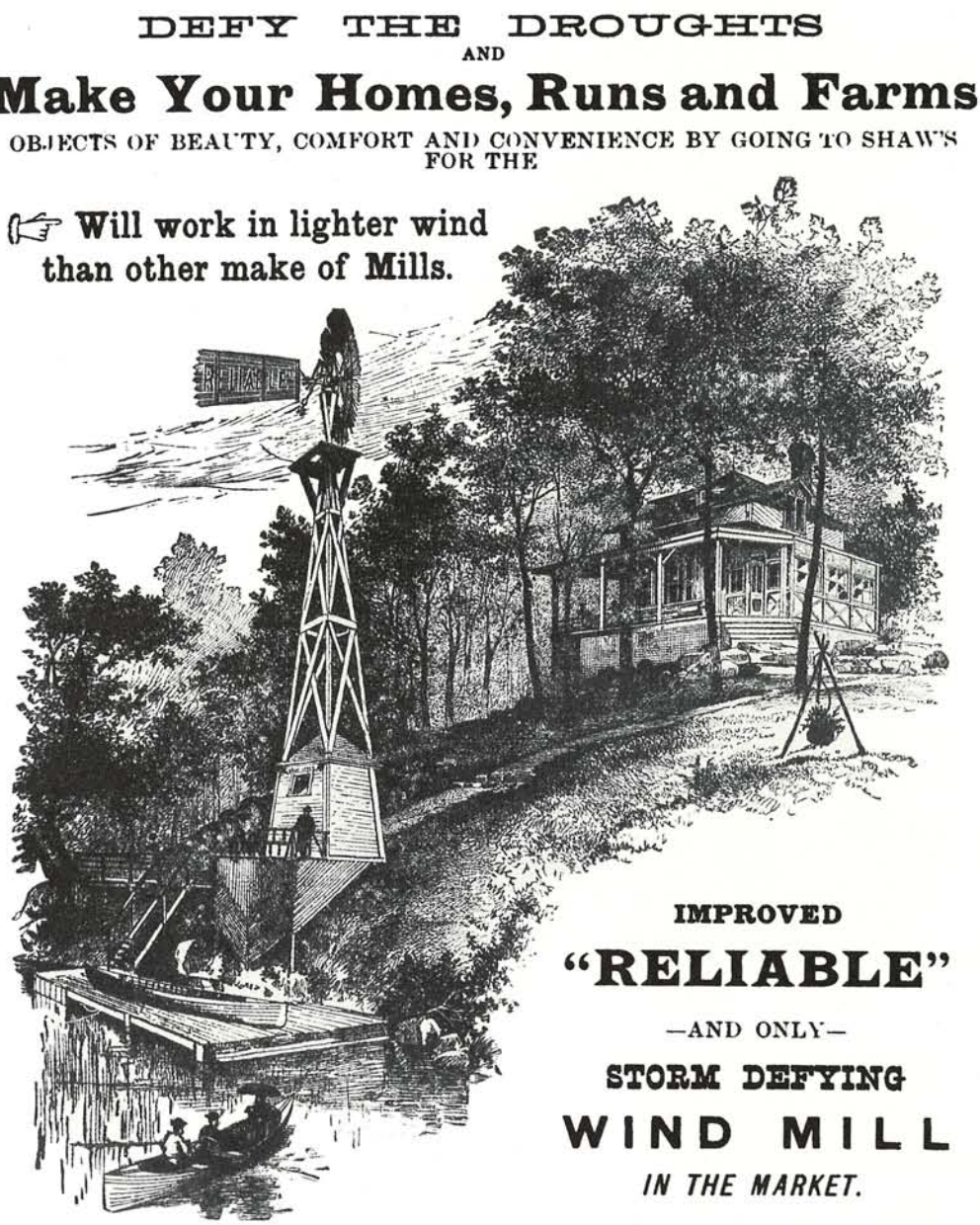


Tamworth basks in electric light. In Melbourne and Sydney private electricity companies already lit the houses of parliament, theatres, retail markets and some inner-city streets. But Tamworth, with 13 kilometres of streets, was the first town to be lit by municipal electricity. Crowds attended the opening celebrations which culminated in athletic sports conducted under four brilliant arc lamps. Sydney Mail, *1 Dec 1888.*

Electric hairbrush. Town and Country Journal, *22 Dec 1888.*

competed for the right to supply generating plant or electric current to warehouses, public libraries, central post offices, markets, hotels, theatres and railway yards. Different companies often represented the rival technologies of overseas electrical giants, such as the Edison, Siemens and Anglo-American Brush companies.

The last remaining technical drawback of electric light was the problem of distribution. Much of the power generated by a dynamo could be lost in conducting it to the point of use; so the effective range of a central generating plant was only one or two city blocks. Moreover, since fluctuations in the rate of consumption by various users could produce alarming fluctuations in voltage throughout the system, only a few consumers could be served from a single generating plant. Both these problems were solved with the introduction, around 1888, of the transformer, which enabled high-voltage alternating current to be carried long distances and then converted to safer voltages at the point of use. A number of suburban municipalities, including Redfern, St Leonards and Hunter's Hill in Sydney and Essendon and Hawthorn in Melbourne, planned to light their streets by electricity. But on 9 November, when the Mayoress ceremonially unlocked a switch, Tamworth in northern New South Wales became the first Australian town to enter the electric age.



Advertisement for a windmill, Boomerang, *Brisbane, 17 Nov 1888.*

WIND POWER

Colonial Australians were immensely impressed by the power of technology to transform their lives. Yet to understand how they actually used the new sources of energy, we must first understand the more primitive forms of power that were replaced. We must view technology, not as a force outside us with a dynamic of its own, but as the response of human beings, with their limited knowledge, resources and foresight, to the demands of their environment. We may speak of 'the march of steam power' or 'the onset of the electric age' but to many a lonely settler facing the difficulties of pioneering, each new invention had to be tested by the immediate needs of the day.

Nowhere, perhaps, was that test as severe as in the remote, low-energy country

of the outback. In 1888 a royal commission was appointed to investigate ways of supplying fresh water to the parched western districts of New South Wales. Countless sheep and cattle had died of thirst over the preceding months in one of the worst droughts of the nineteenth century. Yet just below the surface of this vast, arid plain, great underground reservoirs lay waiting to be tapped. Once a bore had been sunk, it required only a mechanical pump, a small power source and a simple system of troughs and tanks in order to water many thousands of animals.

The experts who appeared before the commission failed to agree on the appropriate source of power. Since each pumping station required a caretaker to maintain the pump and supervise access to the water troughs, some witnesses argued that manpower was the obvious method. A fit man, with a simple McComas hand pump, could water 7000 sheep a day. But the old-timers and hard cases who were prepared to endure the loneliness of outback pumping stations were usually reluctant to undertake the drudgery of eight or ten hours at a hand pump. 'I think there has been a great amount of dissatisfaction with it simply on account of the want of labour in the back country', said one witness of the McComas pump. 'If there is any hard work to be done you cannot get people to do it.' In some parts of the country horses were used to raise underground water either by means of a whip (a system of ropes and pulleys attached to a bucket which was lowered into a well) or by means of a whim attached to a small pump. But the farther men advanced beyond the well-grassed coastal plains, the harder it was to supply working animals with fodder, and in the remote saltbush country horse power also became too expensive. A third power source, particularly favoured by the constant pumping requirements of stations on the most heavily travelled stock routes, was a small steam engine fuelled by local firewood. But firewood was becoming scarce in much of western New South Wales. Even where firewood could be gathered within a kilometre or two of the pump, a horse was usually required to cart it. In the far inland, therefore, where men, fuel and fodder were scarce, even the modest energy requirements of a simple pump could be consumed many times over in transporting that energy to the point of use.

Considering the difficulties of all those conventional power sources, it may now seem odd that the one source of energy that the inland regions had in abundance and that could be easily harnessed to drive a small water pump was scarcely mentioned by the commission's experts. Only one witness, the New South Wales commissioner of roads, Arthur Wood, seems to have recognised the potential of wind power for tapping the artesian basin. 'Windpower', he wrote, 'should prove most economical in its action, and in open plain country where timber for steaming cannot be obtained, the most favourable conditions exist for steady and constant winds'. But this advice was apparently ignored and in their final report the commissioners did not even mention it.

Wind pumps on the modern pattern had first appeared in the United States during the 1860s, and by 1888 they were prominently advertised and commonly used in several parts of Australia. Around the town of Dubbo 'numerous windmills in evergreen gardens' drew water for both domestic and agricultural use from a vast underground reservoir below the valley of the Macquarie River.

As a means of harnessing the artesian waters of the inland wind power certainly had its disadvantages. Arthur Wood observed that it would be necessary to install much larger service tanks to ensure sufficient water for stock when winds were too slight. Yet within a few years the familiar lattice towers with their metal vanes and wig-wag tails were dotted across the horizon through outback New South Wales and Queensland. On the farthest frontier of the most newly settled land, one of the oldest forms of power enjoyed a new lease of life.