Water-Power in Portugal: The Town of Tomar and its Industrial Area

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The river Nabão which runs through the central Portuguese town of Tomar has provided an energy source for industry which can be documented for eight hundred years and presumed to go back to Islamic and Roman times. The water supply was canalised in the fifteenth century to create an artificial industrial island. In this area seven olive-oil factories and six flour-mills were constructed: four of the factories survive though used for different purposes. The site of another is occupied by a turbine-driven electricity station, while the southern end of the zone has a fine water-powered flour-mill built in 1882 and equally fine roller-mill opened in 1912. The central importance of water-power in this area over five hundred years was the subject of an intensive field and documentary study by a team of Australians[1] in 1988 and is a stimulating contrast with the short-lived harnessing of water to colonial industry in Australia.

INTRODUCTION

Every industrial site in the Old World and the New has an energy source. Most energy sources, wind, water, steam, gas, electricity, leave archaeological traces, but none more regularly nor more revealingly than water. In Australia water has been significant in powering rural industry in the colonial period, particularly flour-mills, but it was quickly matched and soon superseded by steam.[2] In Portugal water-power has remained of prime importance not only for rural industry but also for some urban industry into the present.[3] This is despite problems of flood and drought which differ only in severity from the Australian experience. As a result of the continuity of very simple hydraulic devices, alongside much more sophisticated water innovations of the nineteenth and twentieth century, fieldwork in Portugal offers both the historian and the archaeologist uncommon opportunities to see in daily action technologies of work which were largely discarded in Australia a century ago. There are certain features of Portuguese water-exploitation, such as the use of horizontal wheels, which have no counterpart in Australian industrial archaeology, but there is a great deal that is shared experience, long since gone in Australia but alive and tolerably well in Portugal.

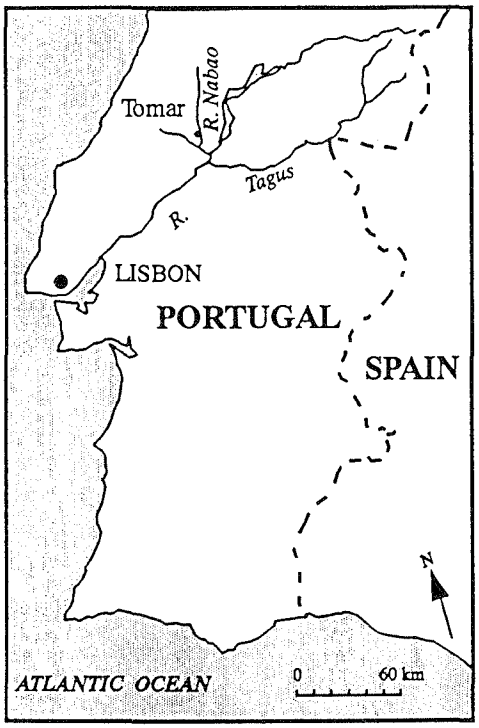

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Fig. 1: The location of Tomar in central Portugal.

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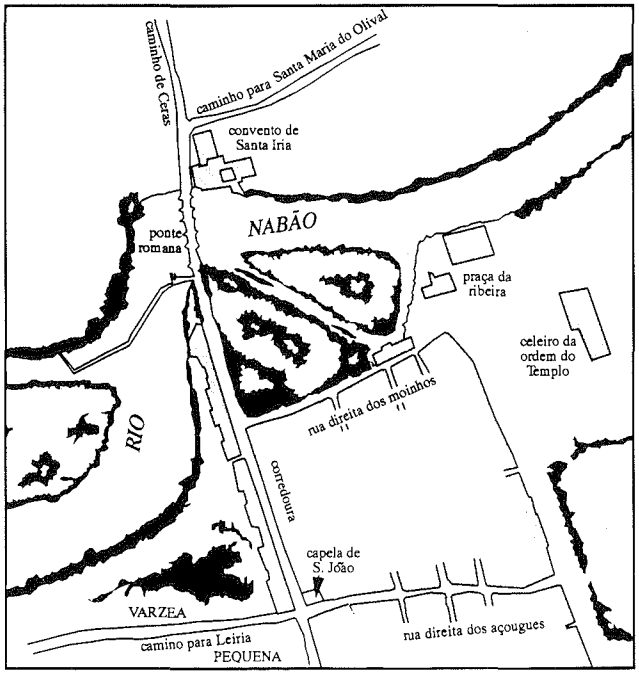

Fig. 2: The incipient town of Tomar and the river Nabão in the thirteenth century. The area reclaimed in the later middle ages lay between the 'rua direita dos moinhos' (mill street) and the main course of the river where Nabao is written on this map. (From da Costa Roas, 1981).

In 1988 the Australian team completed an archaeological survey of an industrial complex in the central Portuguese town of Tomar (Fig. 1). Tomar is a prosperous market-town north of Lisbon, situated strategically on the River Nabão, a medium-sized tributary of the Tagus.[4] Throughout historic times Tomar and its area have produced grain and olives on a significant scale. Grain requires milling, olives crushing, and the Nabão provides a reasonably stable source of energy.

It is most unlikely that the Romans and the Moors, both in their own way masters of hydraulic engineering, with a farming settlement on the east bank of the river Nabão, did not exploit the power of the river. However, despite several archaeological excavations of the Roman town, no evidence has yet been produced to locate early water-diversions, wheel locations and industrialised or irrigated areas.[5] This is partly because of changes in the course of the river, which was much wider in this period, spreading over marshy semi-islands well to the west of the present river-course, both upstream and downstream from the Roman bridge which occupied the site of the present Old Bridge (Fig. 2). The sole survivor of these islands is the park known as the Mouchão, to the north of the bridge. As late as the thirteenth century, similar semi-islands covered the entire area between the present Mill Street (rua dos Moinhos) and the present west bank of the Nabao. Any water-powered industry on the western side of the river must therefore have been located on what is now reclaimed land.

The decisive reversion of this region of Portugal to Christian hands came in the twelfth century when the military order of Knights Templars took over Tomar. The Templars probably inherited flour-mills and certainly built more. The first town charter of 1162 specifically refers to mills with vertical water-wheels.[6] These mills are likely to have been situated at the south-eastern end of the present Mill Street.

By the fifteenth century there had been a great transformation. The Templars had been succeeded by the Order of Christ and the Christian population (still quite small) had expanded towards the river from the shelter of the great castle on the crag west of the river. The head of the Order of Christ at this time was Henry the Navigator, the Infante, and under his powerful direction the old town took its present form on the flats between the castle and the river, leaving the area of Roman, Visigothic and Islamic settlement on the opposite bank to become grazing paddocks and olive-groves under the control of the church (Fig. 3).[7]

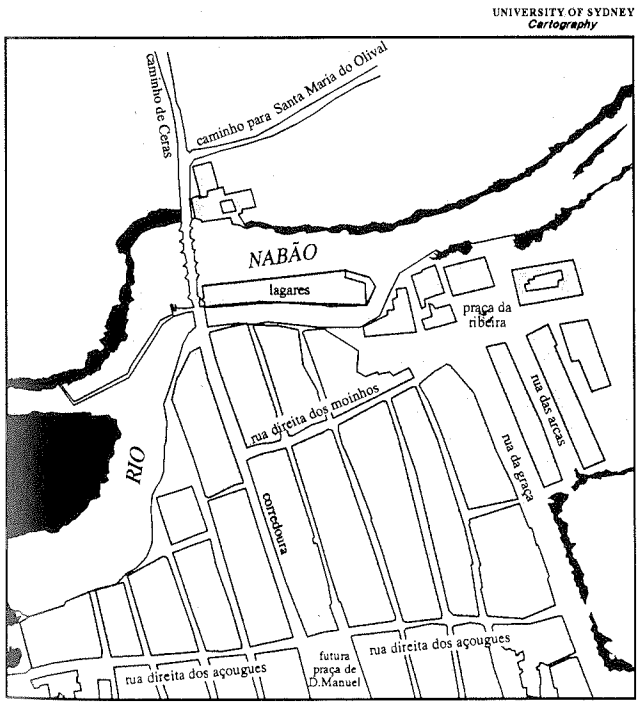

Fig. 3: The developed town of Tomar and the reclamation of the Nabão marshes in the fifteenth century. The canal and the artificial industrial island are clearly shown to the south of the Old Bridge. (From da Costa Rosa, 1981).

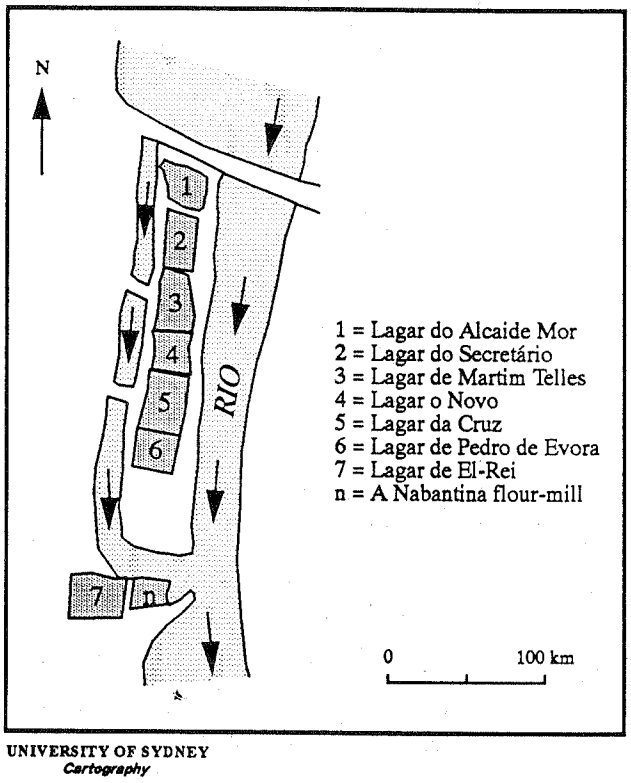

Fig. 5: Sketch plan of the industrial zone in 1903. The Old Bridge is just to the north of lagar 1. Small bridges over the canal are opposite lagars 3 and 5.

These urban developments prompted a rationalisation of water resources. The river Nabão was dammed and an artificial canal some 250 metres long was constructed running parallel to the river on the western side. The dams were a substantial capital investment by the Templars and their successors, the Brothers of Christ. Although in private ownership since the dissolution of the Order of Christ in the 1830s, the major weir just upstream from the Old Bridge is still known today as the Brothers' Weir *(açude dos Frades)* and is still the critical factor in controlling water-power in the town (Fig. 4).[8]

The embankment to the west of the new canal in the fifteenth century formed the edge of the reclaimed swampy area extending eastwards from the old Mill Street. This area soon became tightly packed with urban housing.[9] The long, narrow artificial island created between the canal and the river had from the outset an exclusively industrial nature. Although the actual industries operating there have changed over the centuries, the industrial character of the island is quite unchanged.

THE OLIVE OIL WORKS

From the fifteenth to the nineteenth century this industrial zone and the area on the river immediately to the south housed seven olive-oil works *(lagars)* and five flour-mills, all built in stone and all water-powered. The main part of the artificial island was occupied for four hundred years by six *lagars*, cheek by jowl (Fig. 5). All these buildings are

Fig. 4: The principal late medieval weir in the river Nabao just north of the Old Bridge. The basic structure was the investment of the Brothers of Christ: thus its common name is still the Brothers' weir. The island in the middle background is the Mouchão, the only sand island in the river to survive today. The canal powering the industrial zone goes off to the bottom left while the river flows southwards off to the right.

precisely locatable today by a careful analysis of early documentation coupled with inspection of existing structures and the various channels by which water was diverted from the canal and, after turning a water-wheel, returned to the river. The four surviving buildings represent the result of many rebuildings of the four most northerly *lagars* over the years and are basically eighteenth-century in their external appearance today: one still bears the date 1710. They have been much modified internally but preserve a number of early structural details, such as stone piers to support the wide area of roof, and in one case there is also clear evidence of oil-pressing technology.

None is now used for its original purpose. The *lagar* just beside the Old Bridge has seen service as a laundry, then as a car-maintenance shop and is now an archives store for Mendes Godinho, the firm which owns most of the industrial complex today (Fig. 6). The adjacent two *lagars* became a foundry in the late nineteenth century, with a machine-shop in one and a traditional casting-floor in the other. The fourth has become a private restaurant for the Mendes Godinho firm (Fig. 7). The two adjacent *lagars* were demolished about 1914 after a period of reuse, one as a water-driven saw-mill, the other as successively a distillery and a turner's shop. The site of the first provides a useful open space in Mendes Godinho's sales area. The second site is now occupied by a water-powered private electricity generating plant, the Central Eléctrica (Fig. 8). The seventh olive-oil works of the early modern period lay at the southern end of the industrial area, not on the artificial island but on the reclaimed town-land south of the basin formed by the canal just before it re-entered the Nabão. This *lagar* contined to press olives until 1911 when it was demolished to provide the site for a new flour-mill.[10]

The equipment used in five of these seven *lagars* is known from a documentary source, the advertisements of sale in

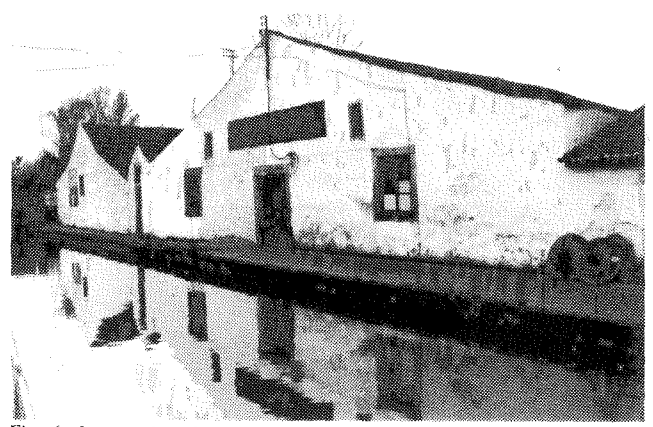

Fig. 6: Lagars 1 and 2 immediately south of the Old Bridge, with the canal in the foreground.

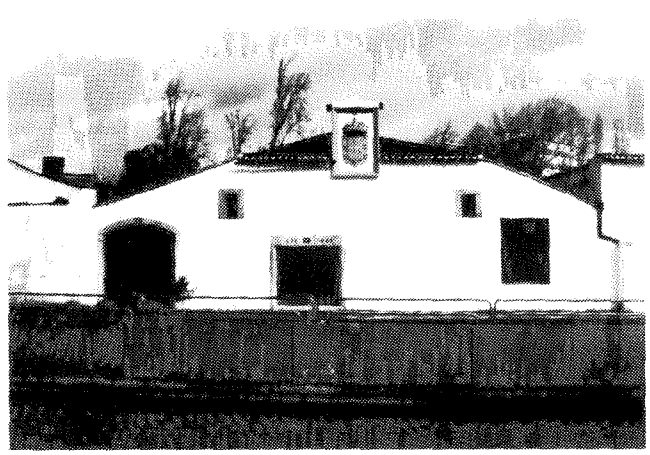

Fig. 7: Lagar 7 with the royal arms of Portugal in an eighteenth century carving. JTP 1903 over the door commemorates the purchase of the lagars by João Torres Pinheiro. The building is now a private restaurant for Mendes Godinho.

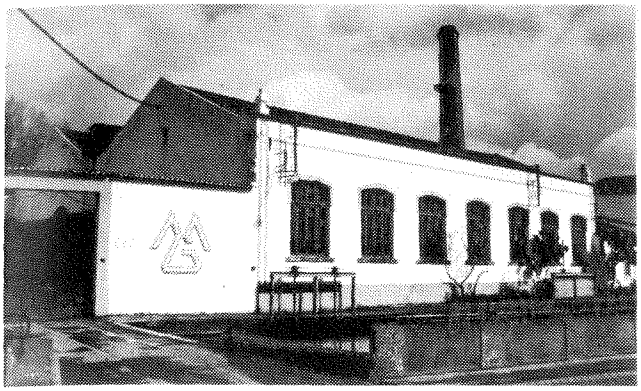

Fig. 8: The Central Eléctrica, the turbine-driven electricity plant privately owned by Mendes Godinho. The canal is in the foreground with the southerly of the two small bridges. Four sluices (two closed, two open in this picture) supply power to the two turbines.

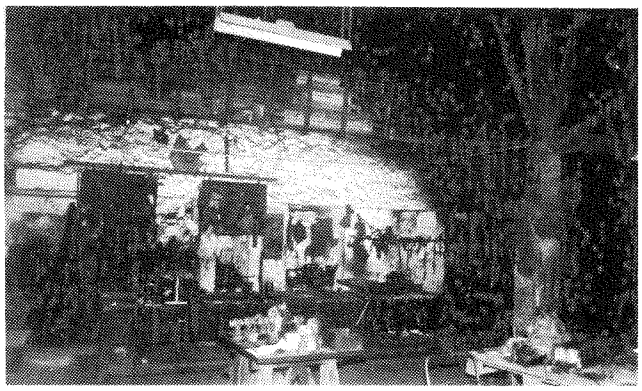

Fig. 11: The stone footings for olive-pressing beams in the eastern wall of lagar 2, now the foundry machine room. Four pairs of stones constitute the surviving evidence for the original seven beams. A work bench is in front of the wall, the blacksmith's forge and anvil to the right. The vertical roof supports on the right are of wood on top of the stone pillar.

1837–38 when all the possessions of the Order of Christ were being secularised.[11] There are two principal traditional methods of squeezing olives commercially: beam-presses and crushing-mills. Examples of both can still be seen in rural parts of Portugal today. The beam-press operates by the slow steady pressure of a vertical crusher attached to a heavy horizontal beam which is pivoted in a substantial stone footing usually within the outside wall of the building. The crushing-mills are normally of the sort which we in Australia describe as Chilean mills, in which a vertical grinding-stone is driven around a large bowl by a central axle connected through gearing to a source of power. In Tomar, as regularly in Portuguese *lagars,* this source of energy was water. The traditional beam-presses, however, required no power save the labour of man or occasionally an animal such as a horse or a donkey, turning a handle to screw the press down on the olives (Fig. 9). The olives were placed on circular mats woven for the purpose, piled high one on another.[12]

The documentary evidence of the sale notices tells us that four of the five *lagars* described in detail had two Chilean mills apiece. All these *lagars* also had beam-presses, in three cases six each, in the fourth (*lagar* 2 on Fig. 5) seven. The fifth *lagar* described had six beam-presses and no Chilean mill: this implies that this *lagar* uniquely had no need of water-power. This building, the former *lagar* de Martim Telles, is still standing (number 3 on Fig. 5) and is now the casting-floor of the foundry. Inspection shows no trace of access to the canal, unlike the adjacent *lagar*, now the machine-shop, which retains the sluice-gate needed to control the water-power for its two Chilean mills.

The written material gives no indication of the precise location of each *lagar*, though it does demonstrate relative locations. Nor does it give information about water-power and it does not hint at the internal lay out of these *lagars*. Location can be made precise by external examination and, in the case of *lagar* 2, formerly the Lagar do Secretario and now the machine-room of the foundry, the industrial plan can be recreated by an intelligent study of vestigial internal features (Fig. 10). Despite the century of reuse as a foundry, this *lagar* retains on its eastern wall four stone footings for olive-oil beam-presses. Four pairs of stones are set vertically on a plinth 0.25 metres above ground level and at right angles to the eastern wall. On top of these vertical stones are stone blocks butted together to form a lintel, 2 metres above ground level. Each vertical stone is pierced by one rectangular hole and one circular hole. They are uniform in size and position and line up in horizontal rows. The round holes in the stones show that a circular wooden shaft extended the row of holes and that between each pair of stones a wooden press-beam projected horizontally

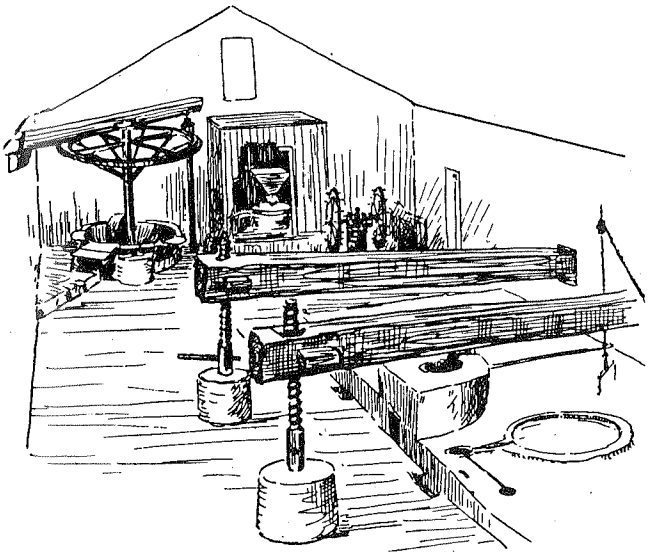

Fig. 9: The olive-oil works at Tecla. As at the Tomar lagars, the Chilean mill is in one corner and the crushing beams are pivoted in the wall. Piles of woven mats laden with olives (not shown here) are placed under the central part of the beam in the circular trough (foreground) from which the oil trickles down a runnel into a bowl below. (From Galhano, 1985).

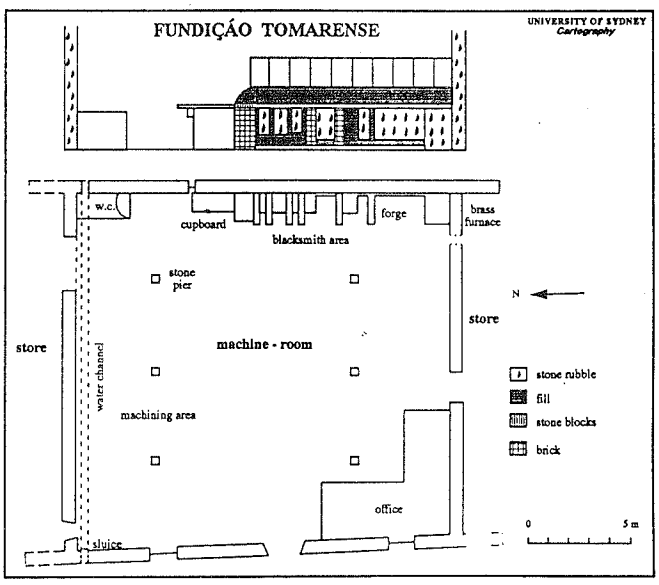

Fig. 10: Plan of the machine room in the Tomar Foundry, formerly the lagar do Secretario. The remains of the stone housing for the olive-pressing beams are on the eastern wall, north of the later forge. An elevation of the eastern wall is shown above.

westwards. Presumably a rectangular beam extended along the row of rectangular holes, either to brace the footings or to prevent the beam from being raised dangerously high (Fig. 11).

The evidence of these press-beam footings confirms that there were seven in all. The intervals between the pairs of stones, from north to south, are 0.70, 0.92 and 0.73 metres. One stone of each of the southernmost pairs has been removed and fill inserted: the depression at the base of a removed stone confirms its former position. If all stones were in position the gaps between the pairs would be regular at approximately 0.7 metres. At the northern end, three more pairs of stones have been taken away to allow the insertion of a concrete wall and a sliding door: brick infill indicates the area where the original stone plinth has been removed. If all seven pairs of stones, and therefore footings for seven beam-presses, were in place, they would leave a space of 3.72 metres between the footing and the southern wall and a space of 4.65 metres between the footing and the northern wall (Fig. 12).

The archaeological evidence therefore shows that seven beam-presses, as advertised in 1837–38, projected from the eastern wall into the centre of the rectangular *lagar*, leaving a substantially larger space to the north than to the south. The metal sluice-gate inside the foundry is in the extreme north-western corner. When the canal outside is drained the water-courses into the old *lagars* can be seen low down on the eastern wall of the canal. The entry of water to *lagar* 2 is only at the place where the sluice-gate is located internally (and there is no provision of water at all for *lagar* 3 which had no Chilean mill). The power-source therefore for *lagar* 2 was in the corner where there was maximum free space left by the great beam-presses, and it is highly likely that the two Chilean mills were erected in this north-western sector of the floor-space.

A very similar lay-out was observed in an intact, though disused, *lagar*, the Lagar de San Guilherme, out in the country near Dornes. Here the single Chilean mill was in a corner directly adjacent to the water-source (in this case a breast-shot vertical wheel), while the beam-presses were bedded in the opposing wall.[13]

THE FLOUR MILLS

Unlike most of the *lagars*, the flour-mills at Tomar in the 1830s and before have almost completely vanished. Our knowledge of these mills is quite good because an inventory compiled for the Order of Christ in 1809 is unusually specific about their capacity and technology.[14] Three of the six mills are described as *azenhas*, three as *moinhos*. The distinction between *azenha* and *moinho* in this case is that the *azenhas* had vertical undershot water-wheels, whereas the *moinhos* were powered by horizontal wheels called *rodizios* (Fig. 13). The milling capacity of the complex was considerable and only flour suitable for bread was produced. Each of the three *azenhas* had two vertical wheels, each wheel driving only one pair of grindstones. The *moinhos* had a larger number of grinding stones, eleven pairs in all, apportioned 4, 3 and 4 among the three mills. Each pair of stones was driven by its own *rodizio*.

Seventeen pairs of stones and eleven water-wheels constitute a substantial milling enterprise and the flour produced was of vital importance to the well-being of Tomar. Without mills on this commercial scale in the eighteenth and nineteenth century the growing town could not have been adequately supplied with flour and bread. Although the number of *azenhas* was reduced to two by 1836, the milling capacity was unaltered, since the two remaining *azenhas* had six pairs of stones just as the three had had thirty years before.[15]

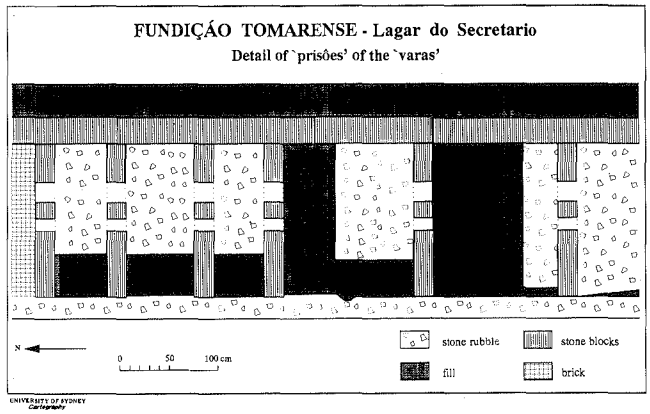

Fig. 12: Detailed elevation of the eastern wall of the former lagar do Secretario showing the footings for the olive-pressing beams.

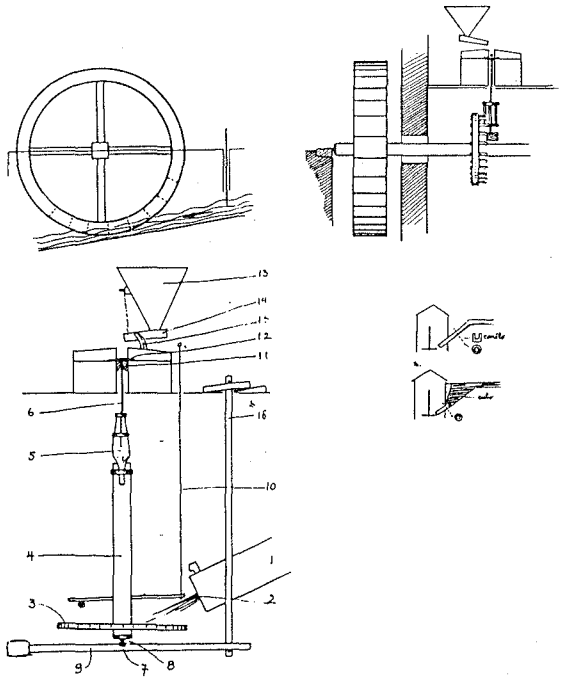

Fig. 13: Sketches (a, b) of an azenha with its vertical directed down at a sharp angle, as shown in the adjacent small drawing (d); the upper drawing shows a pipe leading down from the water source. (From Galhano, et al. 1983).

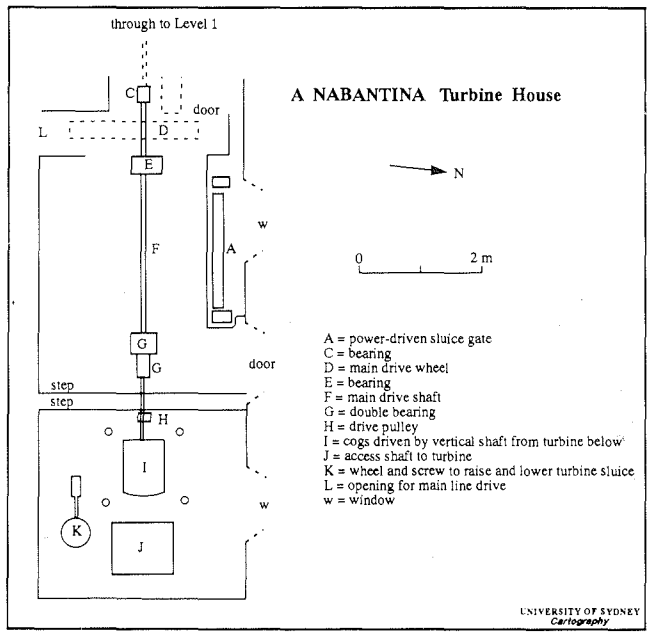

Fig. 14: Plan of the turbine house at the eastern end of A Nabantina flour mill. (From Parris, 1988).

One of these mills was on the site of the present Nabantina mill, but the others just downstream have entirely disappeared. The final vestiges of their foundations and water-systems were swept away by the building of the New Bridge across the Nabão in 1967 and the attendant road-works on the western approaches.

The creation of the present-day mill complex was begun by a prominent Tomarensian, Francisco Alves Cristavão Pinheiro. Over the years 1879 to 1882 this prosperous pharmacist and local politician acquired the various shares of the old mill-buildings which had been divided among the heirs of the original purchasers of the Order of Christ's property.[16]

The buildings bought by Pinheiro included the two-storeyed mill on the site of the Nabantina, just to the east of *lagar* 7. Pinheiro had capital and by the end of 1882 was transforming the old mill with its horizontal wheel into 'an important milling factory' powered by a large vertical wheel.[17] Pinheiro retained the two old vertical-wheel driven *azenhas* to the south. The distinction drawn between the *azenhas* and the factory *(fabrica)* seems to have been one of scale rather than of technology, since the single vertical wheel of the factory was geared to drive at least six pairs of millstones, whereas the *azenhas* had a vertical wheel for each pair of stones. The principle was the same, but the interior of the new factory was more sophisticated.

A French millwright called Le Moine was employed to plan and erect the new mill in 1882–83.[18] The new, iron water-wheel is known only from a photograph,[19] and was some five metres in circumference. It was under-shot and the water supply came from a new mill-race leading south from the basin on the canal.[20] The water-wheel was placed against the eastern wall of the mill, where the turbine house is now. The south-eastern wing of the mill area, which is still there today, was built at an angle of 60 degrees to the main

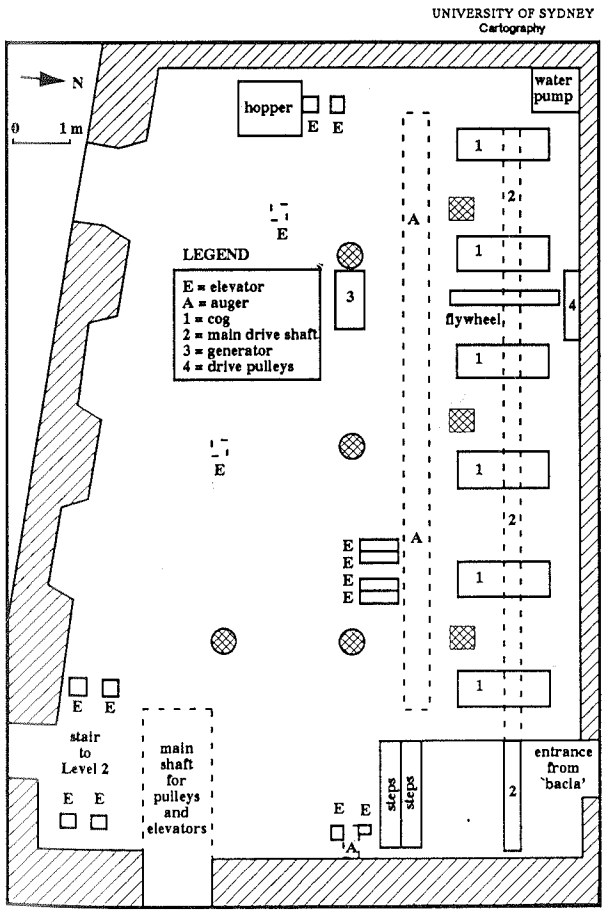

Fig. 15: Plan of the ground floor of A Nabantina flour mill. Plan by Roger Parris.

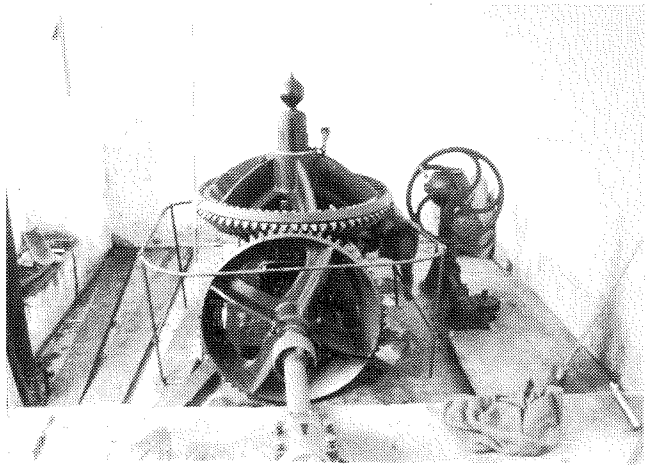

Fig. 16: The eastern end of the turbine room of A Nabantina. The turbine is below the conversion gear in the centre. The lower cogwheel has iron teeth, the upper wheel has easily replaced ash-wood teeth. The vertical wheel on the right is the manual control for an inner sluice gate which brings the turbine into operation. It is still in daily use. The screw mechanism bears makers' plates dated 1917 and 1961. The French firm Teisset Veuve Brault et Chapron installed both the turbines and the control wheel in 1902.

mill, so the effective length of the eastern wall as a wheel-housing was reduced by 1.5 to 2 metres. This left a wall-surface some 7 metres long for the wheel. A doorway into the mill occupied the northern end of the eastern wall, exactly where the present internal doorway from the turbine house into Level 1 of the mill is located today. The axle of the wheel appears on the photograph to be a little above the floor level of the mill and the edge of the wheel comfortably clear of the doorway.

Partly obscured by subsequent changes, there is an arched opening one metre broad in the original eastern wall of the mill: this opening now allows the passage of an horizontal auger from the silo into the mill but is largely blocked by modern bricks. The northern edge of the original aperture is 3.3 metres from the inside northern wall of the mill. It is therefore possible that this aperture is the original housing for the axle of the water-wheel of 1882.

The drive-axle of the wheel which generated 26kW to 30kW (35 to 40 horsepower)[21] was certainly much more central in Level 1 of the mill than the present drive, which leads directly to the conversion gears along the northern side. It is unlikely that the gearings and the stones were centrally placed in the 1883 mill, so it is plausible to assume that the drive was taken from the central axle to the present location of the gearings either by cogwheel or by belt.

The mill building was fully utilised from the start, although the number of grinding-stones varied over the years. In 1895 there were five pairs, by 1902 seven pairs, a mixture of imported French stones (the majority) and native Portuguese stones:[22] today only stones from the French Pyrenees are employed.

The needs of this new, much more highly capitalised mill provoked a series of petty squabbles on the use of water from the river Nabão. The owners of the five *lagars* immediately upstream from the Pinheiro mill reached an agreement in May 1882 to protect the interests of the users of the mill basin adjacent; José Pereira Mendes and other owners of upstream weirs gave similar undertakings the following month; and in July 1883 further assurances were sought from the owners of the various big irrigation wheels on the river to ensure that their weirs did not impede the functioning of the mill-wheel.[23] Pinheiro also owned the critically important Brothers' Weir upstream from the mills and lagars (Fig. 4). He was the object of criticism for his use of the weir, just as he had complained about other weir-holders on the river. In 1885 he was required to reconstruct

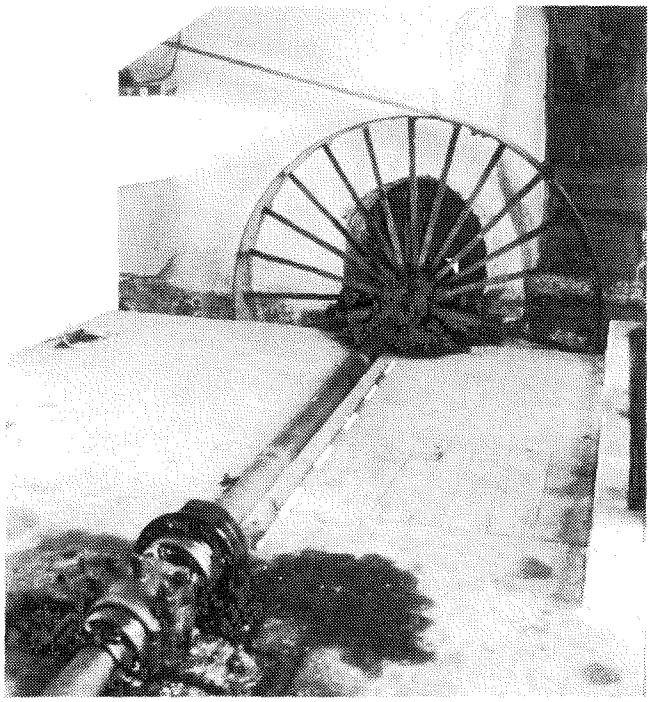

Fig. 17: The western end of the turbine room of A Nabantina showing the main shaft going west from the turbine through the eastern wall of the mill. The wheel, 2.10 m in diameter, drives line-shafting throughout the mill.

the face of the weir to create the present overflow channel: the purpose of this was to abate the nuisance of the increasing build-up of sand in the river below the weir.[24] Two years later, Pinheiro incurred 'the hatred of the local people' by attempting to build a stone and cement barrier at the bridge end, which would prevent the local women from washing laundry on top of the weir: the protests won the day and photographs of the 1890s show the washerwomen still at work.[25]

Ownership of A Nabantina had passed in 1889 to a nephew of the founder, Joao Torres Pinheiro, who was president of the local council from 1890 to 1904.[26] The major industrial innovation instigated by Torres Pinheiro was the conversion of the mill's undershot wheel to a compact and efficient turbine. Turbines were not new to Tomar. Its largest employer, the Royal Textile Factory, had introduced turbines as early as 1874 and two others were in operation by 1895. In the early 1890s the paper factories at Porto do Cavaleiros and Prado had also harnessed the river Nabão to drive turbines.[27] Pinheiro cautiously followed in 1902. He bought a French turbine and installed it at an olive-oil works he owned on the east bank of the Nabão. After a successful trial of the turbine there, Torres Pinheiro dismantled his uncle's wheel at A Nabantina and on 16 August 1902 installed the turbine in its present place.[28] It is striking that the use of steam-power was not even considered: and why should it when water-power still drives the entire mill with great reliability and efficiency today?

The turbine made certain physical changes necessary. The turbine drive had to enter the mill building much closer to the northern wall than previously so a new entry had to be cut in the eastern wall, the entry which is still in use today. This allowed a direct line drive from the conversion gear above the turbine to the gearing for the sets of millstones above (Figs 14-19). It was also necessary to protect the turbine's conversion machinery from the weather: the old wheel had survived happily in the open air. So in 1902 a lean-to shed was erected against the eastern wall of the mill, constructed of wood on a stone footing, with a corrugated iron roof (Fig. 20). This was later superseded by the present

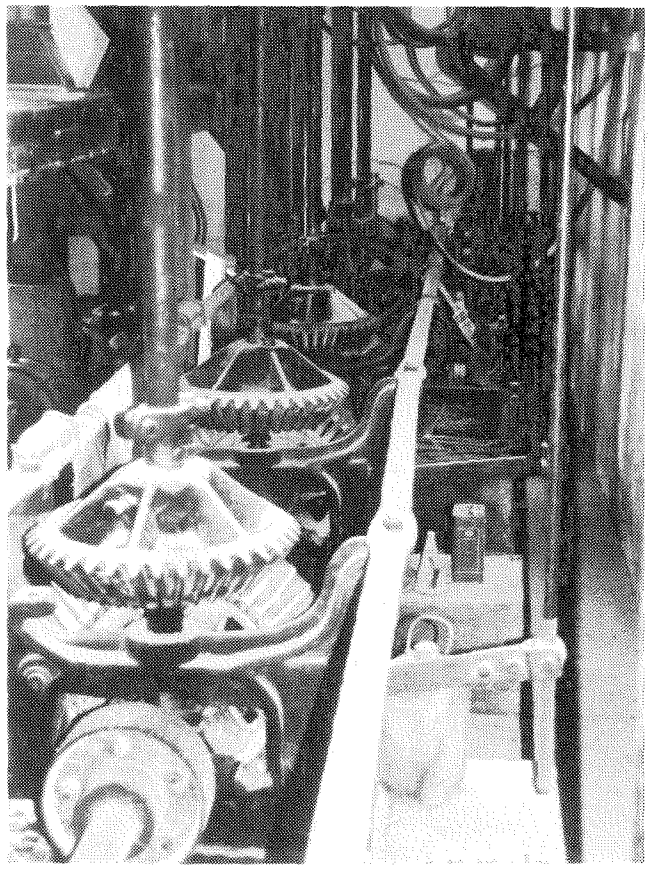

Fig. 18: Five of the six conversion gears in A Nabantina worked by the main shaft from the turbine, viewed from the east. The vertical shafts take the drive to the six pairs of millstsones on the floor above.

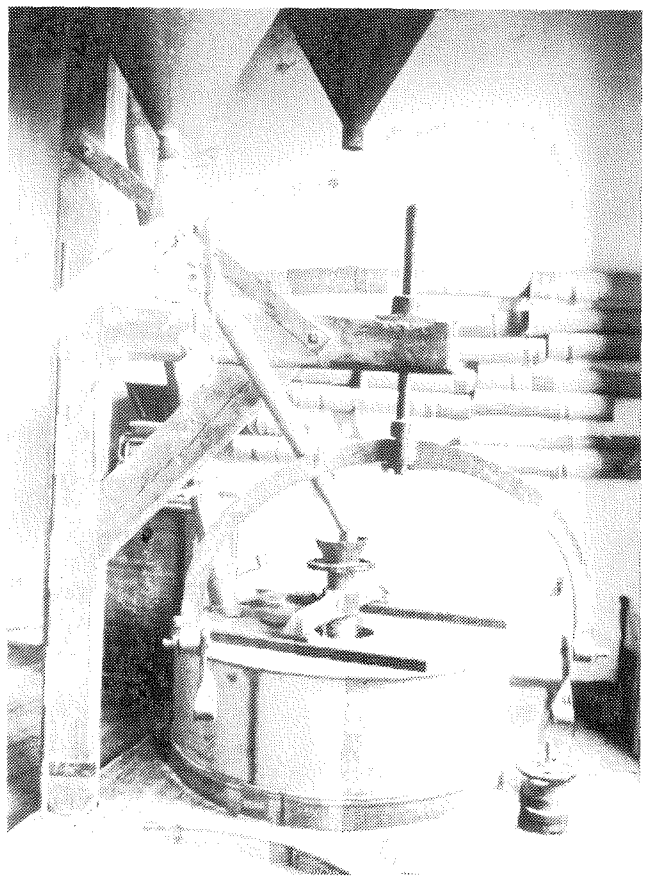

Fig. 19: The most westerly of the six pairs of millstones in A Nabantina. The hopper for gravity feed of the prepared grain is in the centre of the encased stones. Above the stones is a manually operated grapple on a swinging frame to allow the removal of a heavy millstone. It had just been used to remove the upper stone of the adjacent pair in the foreground.

three-storeyed stone wing which completely masks the old eastern wall of the mill (Fig. 21).

When Torres Pinheiro sold the mill in January 1908 to his friend, the local contractor and entrepreneur Manuel Mendes Godinho, he passed on an up-to-date and flourishing business.[29] Almost at once Mendes Godinho laid plans for building a second mill beside A Nabantina. This involved demolishing the last of the working lagars and buying some adjacent land from the municipality, but these plans had to be postponed. A major flood wreaked havoc in the whole industrial area of Tomar in December 1909, doing major damage to A Nabantina and immobilising the water-powered electricity generating plant on the industrial island erected in 1903.[30] Seven months after the flood, Mendes Godinho acquired the electricity plant and the contract to supply the town of Tomar with power and light. In the following year the old lagar beside A Nabantina was pulled down and in May 1912 a new five-storey mill was opened, fully equipped with the latest roller machinery from Switzerland (Fig. 22).[31] The Swiss supplier, Daverio, still operates in Zurich and maintains a model industrial archive. We have the complete order-book entries for 1911-12 and the detailed working drawings of each floor which were done during alterations to the upper floors in 1937.[32] Comparison with the present equipment in the mill shows how little has changed since May 1912 and nothing at all since 1937.

The new mill was named A Portuguesa, perhaps to emphasise that its economic horizons were wider than those of the old mill named after Tomar and the river. The new mill was powered by electricity, supplied by Mendes Godinho's own Central Eléctrica 100 metres to the north (Fig. 8). The electricity cables were run, as they still are today, across the canal to the eastern wall of the mill. Since the electricity was itself generated by water-power, A Portuguesa is still as dependent on the canal for its power as its predecessor, the Lagar de El-Rei, had been, yet it is not reliant on any energy-source outside the control of the Fábricas Mendes Godinho.

From 1912 until the present day the two flour-mills, A Nabantina, grinding by stones, and A Portuguesa, grinding by rollers, have worked in conjunction. No substantial change has taken place in either over the past three-quarters of a century: some Daverio equipment (the governor on Level 1, the separator and winnower, *'tarara'*, on Level 3) was installed in A Nabantina and a roller selector for wheat made by the Austrian firm of Heid was brought in from elsewhere in 1973, but Joao Torres Pinheiro would have no difficulty in recognising his mill of 1902 and Manuel Mendes Godinho could nod with pleasure at all the well-known features of his A Portuguesa as it was in 1912.

The two flour-mills remain complementary, just as they were three quarters of a century ago. The artificial industrial island immediately to the north remains the congested, busy, diverse complex which it has been for half a millennium. The informed planning of the Brothers' Weir and canal south from the Old Bridge remains as impressive in the twentieth century as in the middle ages. The virtually intact Portuguesa roller-mill, still fully operational, is an exemplar of a species best represented in Australia by the roller-mill at Young: but Young lacks the documentation of the mill machinery available from Mendes Godinho's engineers. The no less intact Nabantina mill adjacent, grinding still by traditional stones, offers a most instructive example of the potential of a small nineteenth century turbine drive, rarely employed in Australian industry except in Tasmania.[33] It is also an example of the interdependence of archaeological, photographic and documentary evidence for the clarification of a complex series of physical changes.

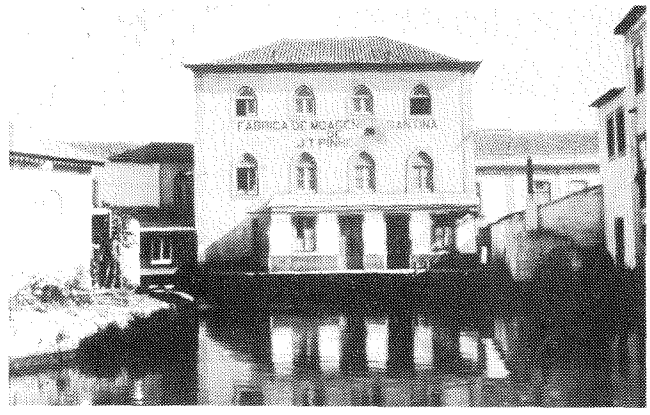

Fig. 20: João Torres Pinheiro's Nabantina flour mill in 1903 after the turbine (housed in the low corrugated iron structure on the left of the three-storey mill) had replaced the vertical wheel. The last working lagar with its hot-water furnace and chimney is partly visible immediately to the right of the mill. (Camara Municipal de Tomar, photograph 58/77).

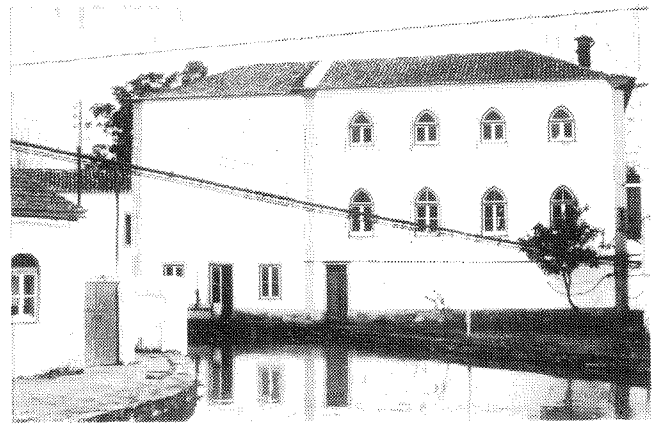

Fig. 21: The Nabantina mill in 1988. A three-story extension largely for storage has incorporated the turbine room, and the lean-to office in front of the north wall has disappeared.

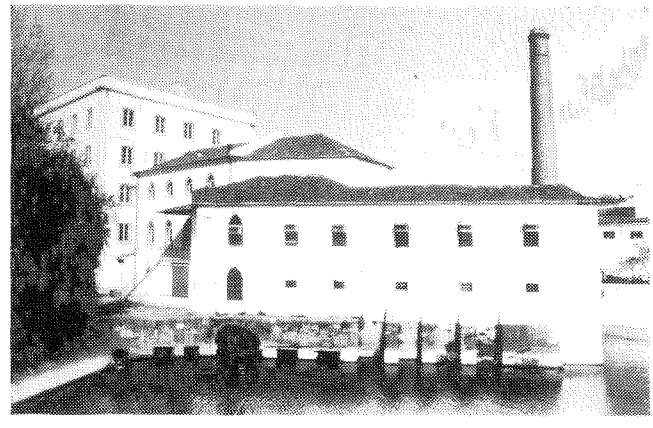

Fig. 22: The Portugesa mill of 1912 is the five-storey building (far left), the old Nabantina three-story mill (centre), and its office-wing extended often last century (front left). The tail-race from the turbine driving the Nabantina is in the lower centre and other disused water-courses use the other five exits. The chimney was built for the electricity plant in the 1920s.

The industrial archaeology of a 400-metre stretch of waterway in the middle of an old Portuguese country town is relevant to the study of water-power and entrepreneurship in colonial Australia. The reasons for success and continuity in harnessing the energy of the river Nabão have much to suggest to anyone exploring the virtual abandonment of water-power on the Australian mainland a century ago.

NOTES

1. The team, headed by Aedeen Cremin and Ian Jack, comprised Kirsty Altenburg, Anne Cannon, John Cannon, Wayne Johnson, Roger Parris and Eve Stenning.
2. Jack 1983 'Flour Mills' in Birmingham, Jack and Jeans *Industrial Archaeology in Australia: Rural Industry* pp.38-50; Dallas 1970 *Water Power – Past and Future;* Linge 1979 *Industrial Awakening: a Geography of Australian Manufacturing 1788 to 1890* pp.43-46, 108-111, 130, 143, 150-152, 320-330, 529-538.
3. Veiga de Oliveira, Galhano and Pereira 1983 *Tecnologia Tradicional Portuguesa: Sistemas de Moagem;* Galhano 1985 *Desenho Etnográfico de Fernando Galhano* vol.1 figs. 126-128, 151-178.
4. Jack and Cremin (eds.) forthcoming *A Arqueologia Industrial da Ribeira da Vila, Tomar.*
5. Salete da Ponte 1985 'Tomar: História e Geografica Humanas no Tempo e no Espaço' in *Arqueologia na Região de Tomar (da prehistória á actualidade)* pp.13-25.
6. Amorim Rosa 1965 *História de Tomar* vol.1 pp.48-49.
7. Da Costa Rosa 1981 'Nascimento e Evolução Urbana de Tomar até as Infante D. Henrique pp.31-52.
8. Amorim Rosa 1964 *Os Lagares e Moinhos da Ribeira da Vila* pp.7-30. Amorim Rosa is too enthusiastic in dating the canal as early as the twelfth century.
9. Romualdo Mela 1981 'Ruas de Tomar e a sua Toponíma' pp.83-84.
10. Sobreiro de Figueiredo e Silva 1943-50 'Os Lagares e Moínhos da Ordem de Cristo' pp.149-55.
11. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar 1137-1925*, vol.2 *1801-1839* pp.430, 437, 462.
12. Da Silva Guimarães 1979 *A Oliveira e o Azeite na Região de Tomar: Usos e Costumes;* Galhano 1985 *Desenho Etnográfico de Fernando Galhano* vol.1 Figs. 200-205.
13. The existence of such an analogy in the hinterland of Tomar supports the conclusions drawn by Kirsty Altenburg and the author at the lagar do Secretario.
14. Cordeiro de Sousa 1943-50 'Ainda os Moínhos da Ordem de Cristo' pp.193-196.
15. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar, 1137-1925* vol.2 *1801-1839* pp.430, 462.
16. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar, 1137-1925* vol.3 *1870-1900* pp. 101, 131, 227; Amorim Rosa 1982 *História de Tomar* vol.2 p.158; Sobreiro de Figueiredo e Silva 1943-50 'Os Lagares e Moínhos da Ordem de Cristo' p.154.
17. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar 1137-1925* vol.3 1870-1900 p.197.
18. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar 1137-1925* vol.3 1870-1900 p.197.
    Amorim Rosa 1982 *História de Tomar* vol.2 p.157.
19. Printed in Custodio and Santos 1985 *O Nabão e Tomar nas Origens da Industrializaçião Portuguesa* p.68. Custodio and Santos calculate the diameter of the wheel to be 8 meters (*ibid.* p.74) but this is a misreading of the evidence.
20. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar 1137-1925* vol.3 1870-1900 p.199,200
21. Vieira da S. Guimarães 1895 *Catalogo da Exposição Concelhia Industrial-Agricola de Thomar* p.21; Sousa 1903 *Noticia Descriptiva e Historica da Cidade de Thomar* p.38; Anonymous January 1987 'Moagem "Nabantina" (a historia duma fábrica)' p.15.
22. Vieira da S. Guimarïes 1895 *Cataloga da Exposiçio Concelhia Industrial-Agricola de Thomar* p.21; Anonymous January 1987, 'Moagem "Nabantina" (a historia duma fábrica)' p.15.
23. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar 1137-1925* vol.3 1870-1900 p.199, 200, 214.
24. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar 1137-1925* vol.3 1870-1900 p.242-243.
25. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar 1137-1925* vol.3 1870-1900 p.258; *A Verdade* 27 Fabruary 1887; Silva Magalhães photograph album, Biblioteca Municipal de Tomar.
26. Torres Pinheiro 1917 *Quatorze Annos de Administração Municipal e Alguns Subsidios para a Historia de Thomar* pp.12-15.
27. Vieira da S. Guimarães 1985 *Catagolo da Exposição Concelhia Industrial – Agricola de Thomar pp.11-12, 14;* Custódio and Santos *1985 O Nabão e Tomar nas Origens de Industrialização Portuguesa* pp.76-77.
28. Sousa 1903 *Noticia Descriptiva e Historica da Cidade de Thomar* p.38; the date 16 August 1902 is inscribed on the floor of the turbine-house of A Nabantina.
29. Anonymous May 1987 'Manuel Mendes Godinho (1849-1924)' pp.2-3.
30. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar 1137-1925* vol.9 1901-1925 p.199, 203-205.
31. Amorim Rosa (ed.) 1940-74 *Anais do Municipio de Tomar 1137-1925* vol.9 1901-1925 p.298.
32. My thanks to Eve Stenning for obtaining this information.
33. Dallas 1970 *Water Power – Past and Future* pp.127-128.

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