The Living Archaeology of Work: a Traditional Foundry in Central Portugal

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Portugal offers glimpses of old technologies still regularly and unselfconsciously at work. An iron foundry created a century ago in buildings previously used as olive-oil factories is an illuminating example of practices once common in Australia or Britain. A small group of Australians doing a more general project on the industrial archaeology of central Tomar recorded a day-long iron-casting by seventeen Portuguese workers who filled a hundred moulds in the most labour-intensive way without protective clothing, weaving patterns among the rows of moulds under the authoritative eye of a skillful foreman. This experience gave a rare insight into the functioning of a workplace which is usually studied by industrial archaeologists as a dead and silent site. The authors are respectively consultant archaeologist and Associate Professor of History at the University of Sydney.

The old industrial area of the central Portuguese town of Tomar has been discussed in general in volume 7 (1989) of this journal. The portion of the artificial industrial island immediately south of the Old Bridge in Tomar is occupied by a row of four former olive-oil manufactories (lagars)(See Fig. 1 for location)*. Throughout the twentieth century the middle two of these buildings have been used as a foundry (Fig. 2).

THE TOMAR FOUNDRY

The northmost of the two lagars, now the machine-room, is a low-slung building some 18 metres in breadth fronting onto the medieval canal, the source of water-power for the Chilean mills which had crushed olives in earlier times. The date 1710, just legible still over the front door, is almost certainly the date of the last substantial rebuilding of the old lagar. The property, like the rest of this section of the industrial zone, was sold to Joao Torres Pinheiro in 1903 and an iron casting on the lintel, no doubt made in this foundry, commemorates the event with 'JTP 1903' (Fig. 3).[1]

The Lagar de Martim Telles next door (now the casting floor) has suffered more changes, both internal and external, than its neighbour. Soon after 1903 Joao Torres Pinheiro removed the stone carved with the armillary sphere of the sixteenth century patron of Tomar, Dom Manuel. This stone had projected above the roofline in the centre frontage. Pinheiro altered the roofline to make the present simple pitched roof and installed the present gesso copy of the armillary sphere carving slightly north of centre on the rebuilt frontage (Fig. 4).[2]

Between these two former lagars is a very narrow building with a simple low pitched roof (Fig. 4), running the full depth of the lagars. Another similar building lies to the north of the machine-room (Fig. 2). Both these narrow structures, which were originally living quarters for the oil-presser, have been combined with the lagars to form internally connecting work and storage areas.

The northerly domestic building is now used as a changing-room and washroom for the workmen in the foundry, and a number of miscellaneous things are stored there. The adjacent lagar is now the machine-room (Fig. 5), with a wide range of machinery and tools, metal, a wheelbarrow, a horse-cart, a large ceramic water container and a small managerial office. This building reveals the only archaeological evidence for the original use of the lagars. Along the eastern wall is a row of stone blocks set on a plinth which are the remains of the olive oil presses, and at the western corner of the building is a sluice where the water was formerly diverted from the canal outside to power the Chilean mills. When the building was altered to a machining shop a smithy was constructed, and the stone blocks of the oil presses at the northern end of the building were adapted to house the forge. A furnace for the brass foundry was constructed next to the smithy, the door being located in the north-western corner of the machine shop and the furnace being housed parallel to the eastern wall in the adjacent southern domestic building. This building is a store area incorporated in function though not structurally with the southern lagar, which is the casting room of the foundry (Fig. 6).

The row of buildings was leased and the foundry constructed by the firm of Luiz da Silva around 1900. A photograph taken shortly after 1903 shows painted on the stone front 'Fundiçao de ferro e bronze' (iron and brass foundry) and below, on a rectangular wooden panel, 'Serralharia mechanica de Luiz da Silva & Ca' (machine-shop of Luiz da Silva & Co.) (Fig. 7). In a pleasing continuity, the firm is known to have produced cast-iron oil-presses for surviving lagars elsewhere.[3] An early photograph shows a newly manufactured and fully assembled water-wheel for field irrigation waiting to be delivered to a local farmer (Fig. 7). The largest castings known to have been done by da Silva were the iron columns for the new roller-mill, A Portuguesa, built in 1912 by their new landlord, Manuel Mendes Godinho. The history of the foundry has been continuous, but the name has now changed to the 'Fundiçao Tomarense' (Tomar Foundry).

* *All Figures have been grouped at the end of the text*

THE FOUNDRY IN ACTION

In May 1988, while the whole industrial area was being surveyed by an Australian team led by Aedeen Cremin and Ian Jack, there was an opportunity to see the foundry in action. It was at once clear that what we were witnessing was a profoundly anachronistic scene. The processes of work by the seventeen men in the foundry that day offered a means to comprehend better the functioning of the dead foundries encountered by industrial archaeologists in Australia and elsewhere. Kirsty Altenburg recorded the activities in the casting-room throughout the smelt while Ian Jack maintained a photographic record both on colour slide and black-and-white print film. Because the men were constantly handling molten metal without protective clothing, it was not normally possible to use a flash, lest it caused an accident, so the entire operation was recorded by the light of the hot iron and the dim natural light through the roof-glass of the casting-shed. The shed's front doors are not normally open during casting (although they are directly opposite the only bridge over the canal servicing the foundry), and there are only two tiny windows.

The blast furnace is located midway along the eastern wall of the casting-shed. The cold air-blast was provided by a fan, belt-driven from an electric motor in the north-western corner. This motor, driving air in a pipe under the floor, whirred away throughout the day. The furnace was top-loaded within the shed from a platform reached only by ladder. Coke, flux and scrap metal were loaded manually into the furnace by two men, who remained on the platform for most of the smelt. The furnace was lit in the morning and took all morning to reach a satisfactory stage for regular tapping. At this early stage two portable metal sheets were in place on the north side of the blast furnace, opposite the tap-hole, which was not yet blocked. Their purpose was to deflect sparks and cinders which from time to time flew from the tap-hole. Liquid metal in small quantities was collected in a ladle placed in sand on the floor below the tap-hole and slag was pulled away across the floor by a man using a long metal scraper.

Sand-moulds in casting-boxes had been prepared over the previous week and had been laid out in carefully planned order all over the 150 square metres of floor available. There were a hundred moulds in all, in a wide variety of circular, rectangular and square boxes. All were clamped tightly with wooden chocks and many had metal ingots as additional weights on top (Fig. 8).

When casting began in earnest in the afternoon, the spout from the furnace's tap-hole was dampened with water and tamped down with fresh clay while the tap-hole was blocked. Each of the basic hand-ladles was operated by two men. The end of the ladle which pointed east when it was being filled at the furnace had a forked handle to control the tipping of the ladle, the western end a simple hand-hold (Fig. 9). On temporary metal supports inserted in flanges on the furnace columns, three hand-ladles were balanced (Fig. 9). The most northerly of these balanced ladles was directly below the spout of the tap-hole. Below on the sand there was another ladle to collect the minimal amount of metal spilled while ladles were being changed.

The protective metal sheets were moved from the north to the southern side of the furnace and pouring began. When the first ladle was sufficiently full of molten metal, two men carried it away to pour into a mould while another two men deftly moved the next ladle under the spout with barely a drop spilled. When the first ladle was returned it contained a little metal which was poured into the ladle then being filled under the spout. The handle of the first ladle was then passed quickly through the space between the spout and the top of the ladle being filled, that is to say through the flow of molten metal, and was placed in waiting on the supports for refilling. Four hand-ladles were in constant use to maximise the efficiency of the operation.

The pairs of men bearing the ladles followed carefully planned paths among the hundred moulds under the authoritative eye of the foreman. They filled mould after mould without the aid of a runner (a sort of funnel for easier pouring): as a result a certain amount of metal was spilt on the top of several casting-boxes.

After about an hour of steady work both by the men on the floor and by the two men top-loading the furnace, some servicing of the furnace was needed. The tap-hole on the north was closed and the door on the southern side was opened, releasing an exciting torrent of sparks and cinders onto the two protective metal sheets. Surplus slag was cleared out in the 30-second operation.

The tap-hole was reopened and the casting continued. A much larger hand-ladle (known in English foundries as a 'shank') was now brought in to fill four big moulds in the centre of the casting-floor.[4] The shank was not brought to the furnace, but was positioned initially beside the fourth of the moulds, the one farthest from the furnace. The shank was supported on a metal frame, which had screws attached on each of its two verticals to adjust the height of the ladle. The shank was filled as rapidly as possible by five loads from the standard hand-ladles. Because of the height of the shank on its stand this involved virtuosic handling of the smaller ladles above shoulder-level by five men and a boy skimming off slag. To complete the filling of the four large moulds this dangerous operation of emptying a ladle into the shank had to be repeated twenty times (Fig. 10).

When the shank was tipped to fill the big moulds, as many as three men took the double hand-hold (which was arranged to be at the western end, unlike the arrangement with the ladles), while one man controlled the eastern handle (Fig. 11). As with casting from the small ladles, an apprentice with a metal rod restrained the portions of slag floating on top from leaving the shank and causing potential damage to the moulding (Fig. 12).

After a further half-hour slag again had to be removed from the southern side of the furnace and periodic stoking with a long iron rod was needed through circular vents in the eastern and western sides of the furnace. As the quantity of molten metal in the furnace diminished the foreman himself raked the area around the tap-hole to remove the build-up of slag. After the blast was turned off at 5 p.m. one further hand-ladle was filled by a final clearing of the tap-hole and its spout.

The casting was now over after a long, hot day of ceaseless toil. But the work was not yet finished. The ladles were removed from the furnace and slipped free from their handling frames: both frames and ladles were stacked against the northern end of the eastern wall. The metal rectangular support for the ladles was also removed from the furnace and stacked against the eastern wall. At the furnace hand-levering with rods at the southern side sent slag running out at the northern side. The rectangular metal doors underneath the furnace were opened and latched up horizontally. Rods inserted into the southern entrance encouraged slag and half-burnt coke to fall from the base of the furnace onto the earth floor, where they were quenched with bucketsful of cold water from an adjacent tap. Six men and the foreman were occupied in this task. One large portion of slag was isolated from the furnace area and stored separately north of the furnace, presumably for reuse as flux.

All together sixteen men and the foreman were involved in this day-long casting, lit by daylight through the roof and by the glow of metal. Refreshment was available not from the tap near the furnace but from the large ceramic jar in the machine-room adjacent, where the water was drunk from a communal tin mug. The finished castings from a previous day's work were still being removed in a hand-loaded wheelbarrow through the door of the machine-room.

Early the following morning the moulds were opened. After the weights on top of the moulds were removed and stacked manually in the store-room adjacent (the old lagar-keeper's house), the clamps were removed, the top of the casting-box was pushed off and sand was knocked out with a hammer. Pins or wires around the cast were removed and sorted by size into buckets, which were then emptied into wooden bins for future reuse. Apprentices carried the castings to a heap around the furnace, while the casting-boxes were neatly stacked in piles by shape and size. The metal pins attached to the castings were removed by a man using a crowbar. Altogether some six men and the foreman were involved in removing the castings, while the other ten employees returned to their other tasks in various parts of the machine-room. It was a most striking feature of the whole operation that, while each man clearly was a specialist, no one was a specialist in one thing alone: all aspects of the foundry, both casting and machine-working, were operated by the same versatile group of seventeen men.

The Tomar Foundry is an exceedingly impressive, though labour intensive, operation. To see the entire work process of a casting over 36 hours is to share a common sight of the 1890s re-enacted long after it has become superseded throughout the developed world. Descriptions of the workings of a casting foundry in Victorian manuals such as Tomlinson's Cyclopaedia[5] show that the Tomar works is exceptionally unmechanised (while being also particularly effective). Tomar lacks a crane-ladle, for example, an essential feature of most nineteenth century foundries producing castings of a largish size. It seems almost certain that the casting of the flour-mill pillars in 1913 was done in open horizontal moulds on the floor, not in the vertical moulds which were preferred elsewhere for long cylinders or shafts.[6]

COMPARISON WITH THE PHOENIX FOUNDRY, URALLA, NSW

The Phoenix foundry at Uralla in New South Wales offers an excellent comparison with the Tomar works.[7] This Australian foundry is exactly contemporary with that of Luiz da Silva, opening in 1898, although using some earlier equipment. Like the Tomar operation, an iron-casting furnace stood beside a sanded casting-floor, with a machine-shop and smithy immediately adjacent (Fig. 13). The bronze casting-shop at Uralla was at a lower level with its own furnace. Tomar no longer seems to cast in brass or bronze, but the remains of the brass furnace are in the south-eastern corner of the machine-room near the smithy and in the store-room adjacent. The physical relationship of a brass/bronze furnace and the main casting floor can be seen also at Laycock's 1917 foundry at Bathurst in New South Wales, recorded by John Gibson in 1985.[8] At Laycock's the iron-smelting cupola actually lay outside the rectangular slab hut which housed the foundry: within the shed the machine-shop lay at one end, the blacksmith's shop and brass foundry at the other end, with the casting floor in the extensive middle area (Fig. 14). Since the brass-casting required a much smaller area than iron-casting, the physical contiguity of the smithy and brass-furnace at both Tomar and Bathurst and the physical separation of the two casting-floors at Tomar and Uralla are sensible, pragmatic uses of space.

Like Laycock's, Uralla foundry was a much smaller operation than the Fundiçao Tomarense. The Phoenix was largely a Young family business, with a maximum of six men working in the foundry on a casting day, only a third of the number fully employed at Tomar.[9] When Margaret Barr (now Margaret Simpson) recorded Uralla in 1975, she was shown photographs of small hand-ladles being used in the recent past by two men and a skimmer as at Tomar (Fig. 15). The design of the ladles and their handles was basically the same as in Portugal, except that the handles in Portugal were substantially longer, giving the men more protection from the heat of the molten metal.

Despite its much more modest scale, the Uralla foundry had a more mechanised large ladle than Tomar. The large Phoenix ladle could be hauled up on a pulley system by chain and hook to a suitable height and taken across the casting-floor by a crane running along a beam (Fig. 16). In this way the dangerous and time-consuming filling of the shank by twenty loads from the small ladles which was so spectacular a part of the Portuguese casting could be avoided. The Uralla arrangements had the further advantage of drawing the iron direct from the furnace at a consistently high temperature.

The provision of a crane was common in Victorian foundries in England and certainly existed quite early in Australia. When William Bourne, who ran a foundry at Street's Wharf near the foot of Market Street in Sussex Street, Sydney,[10] sought a loan from Sir John Jamison of Regentville in 1840, he offered his entire establishment as security and provided a complete inventory of the contents. Unlike the Tomar Foundry, Bourne had a large crane, valued at thirty pounds, in his casting-room, along with mould-boxes and a 'large pair of bellows ... for the foundry blast': in his machine-room he had a five horse-power steam engine and boiler, a drilling machine, a very expensive boring mill 'complete with wheels, screw carriage, 5 boring bars, 10 boring head, one large rest, 8 head with cutters holding down bolts etc', valued at 365 pounds, a brand new turning lathe 'with slide rest and turning tools with bed 21 feet long', a small turning lathe and a frame for turning large wheels, for which he had many patterns. In the blacksmith's shop, Bourne had three pairs of bellows and three anvils.[11]

William Bourne was operating a business in Sussex Street 150 years ago which bears many similarities to the foundry at Tomar today. The principal difference, beyond the source of energy for the machine-shop, lies in the greater mechanisation of Bourne's foundry. The installation of two cranes had made good economic sense to Bourne, as it did to Young at Uralla sixty years later. The absence of a lifting device for the safety and convenience of the casting-shop at Tomar today is much more striking in this context.

At Tomar one is witnessing an unusually labour-intensive system but one which gives perfectly satisfactory technical and economic results. Even if the Phoenix foundry at Uralla were to return to regular operation (which seems highly unlikely), the small size of its casting-floor, the small number of its personnel and its use of mechanical devices would make it a surviving analogue to Tomar but by no means a replica of the Tomar operation.

There are straightforward reasons for the use of a crane. The crane at Uralla compensates for the smallness of the available work-force; just as the hand-operated wooden crane installed in 1872 in the foundry at Llanberis, the Caernarvonshire slate quarry complex (closed in 1969),

was a modest mechanisation suitable for this plant.[12] The Tomar foundry is salutary in demonstrating that, given abundant cheap labour, even this degree of mechanisation was not of critical importance in making a business viable.

The Tomar operation is valuable as a record of surviving mental attitudes towards the use of labour in the workplace. These attitudes are illustrated in the reliance on physical labour to perform all the tasks with the minimum use of mechanical devices, as evidenced in the lack of a crane-ladle; in the transport of castings and completed machined items in a wheelbarrow back and forth between the two buildings; in the versatility of the specialised labour force; and in the complete disregard for minimum safety requirements. The interweaving of seventeen Portuguese men, the sheer authority of the virtuosic foreman, the spectacle of the molten iron falling into the shank from a manhandled ladle held shoulder-high again and again and again, all this and the total planning and execution of the Tomar process provide a living archaeology of the work-place which is as rare as it is vivid.

NOTES

1. Rosa 1964:29.
2. Sousa 1903:255.
3. Guimaraes 1979:77.
4. Cf. Tomlinson 1866: vol.3 p.345.
5. Tomlinson 1866: vol.3 pp.338-350.
6. Tomlinson 1866: vol.3 p.345.
7. Barr 1975:6-9 and Figs. 1-22.
8. Gibson 1988: vol.2 p.158 App.J 2.
9. Barr 1975:6.
10. Low 1844:21.
11. Mitchell Library, Norton Smith Papers, Gibbes' Trust, A 5317-2 no.111 pp.167-169.
12. Rees 1975:237.

All photographs by R.I. Jack, 1988, unless otherwise attributed.

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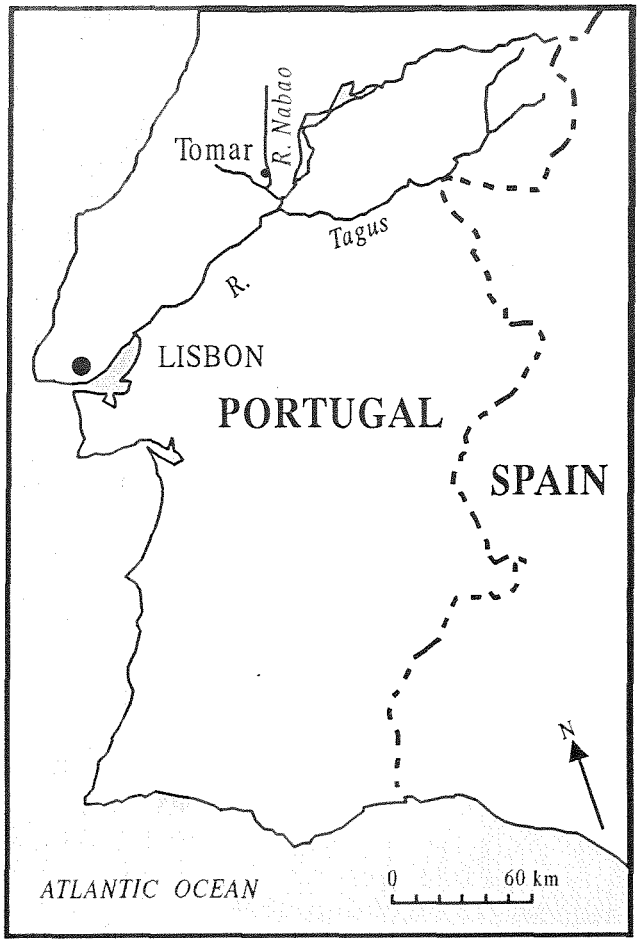

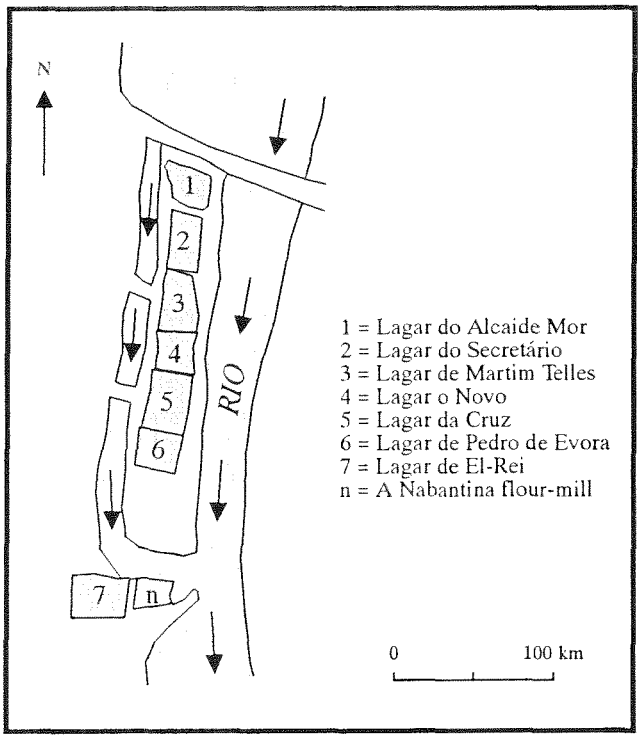

Fig. 1: The location of Tomar in central Portugal, and a sketch plan of the industrial zone in 1903. The Old Bridge is just to the north of lagar 1. Small bridges over the canal are opposite lagars 3 and 5.

Fig. 2: The industrial canal in Tomar, looking south. Three of the four surviving olive-oil manufactories (lagars) are on the left front. The foundry occupies the most northerly of the buildings shown. From left to right these are the low, narrow lagar-keeper's lodging; the Lagar do Secretario, lagar two (with the foundry sign over the door); the next lagar-keeper's house with a low projecting tiled roof; and the Lagar de Martim Telles, lagar three (with the modelling of an armillary sphere on the wall over the doorway).

Fig. 3: The entrance to the machine-room of the foundry with the faded sign announcing 'Serralheria mecanica. Fundiçao Tomarense' (Machine-shop. Tomar Foundry). The cast-iron inscription on the stone lintel of the door, JTP 1903, refers to the purchase of the building (and others adjacent) by Joao Torres Pinheiro. Between JTP and 1903 is the faint impression of the date 1710.

Fig. 4: The casting-shed of the Tomar Foundry. The bridge over the canal gives vehicles access from the town to this part of the industrial island. The roofline of this former olive-oil manufactory was remodelled by Joao Torres Pinheiro soon after 1903. The two castings lying to the left against the wall are two of the four large castings made with use of the 'shank' described in the paper.

Fig. 5: A general view of the machine-room of the Tomar Foundry from the south. The door to the canal stands open to the extreme left. The wooden beams on stone bases support the 18-metre span of roof. The line-driven machinery is in the background, in the foreground the wheel-barrow used for carrying complete castings from the adjacent casting-shed. The horse-cart employed for deliveries until recently is partly visible on the front right.

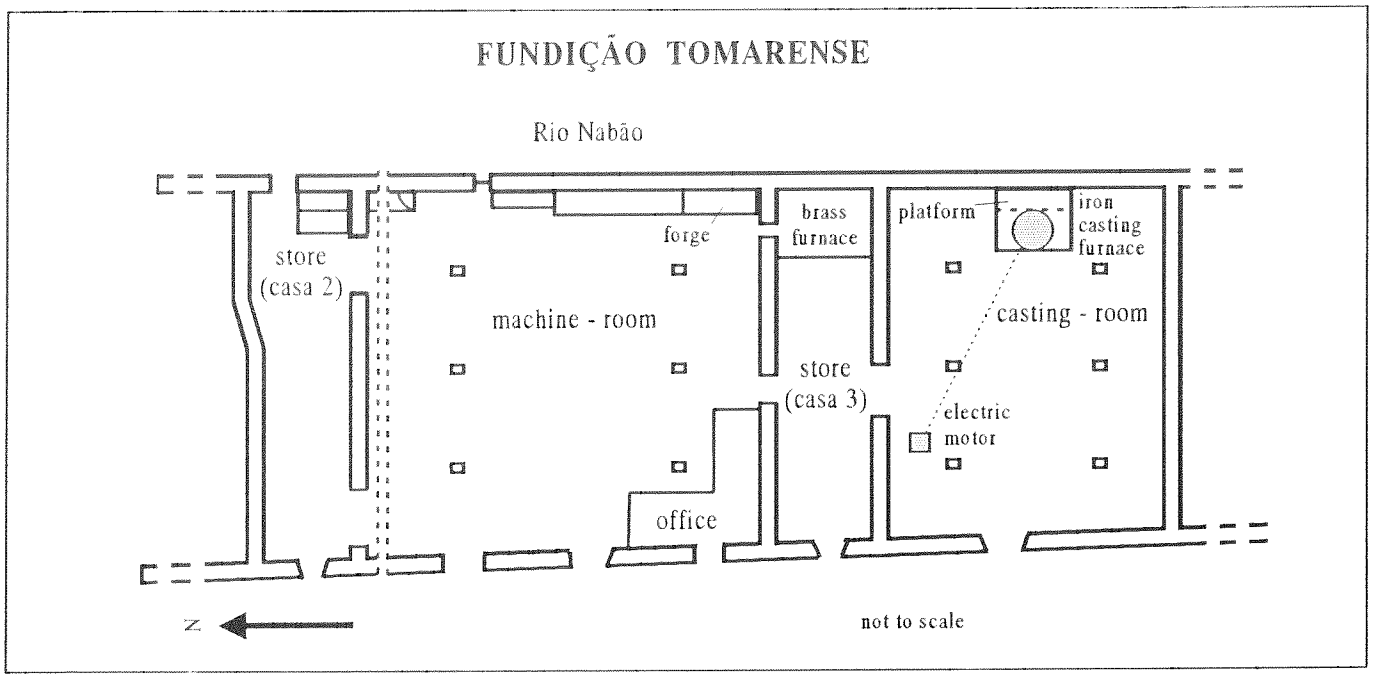

Fig. 6: Plan of the entire foundry complex at Tomar. (K. Altenburg)

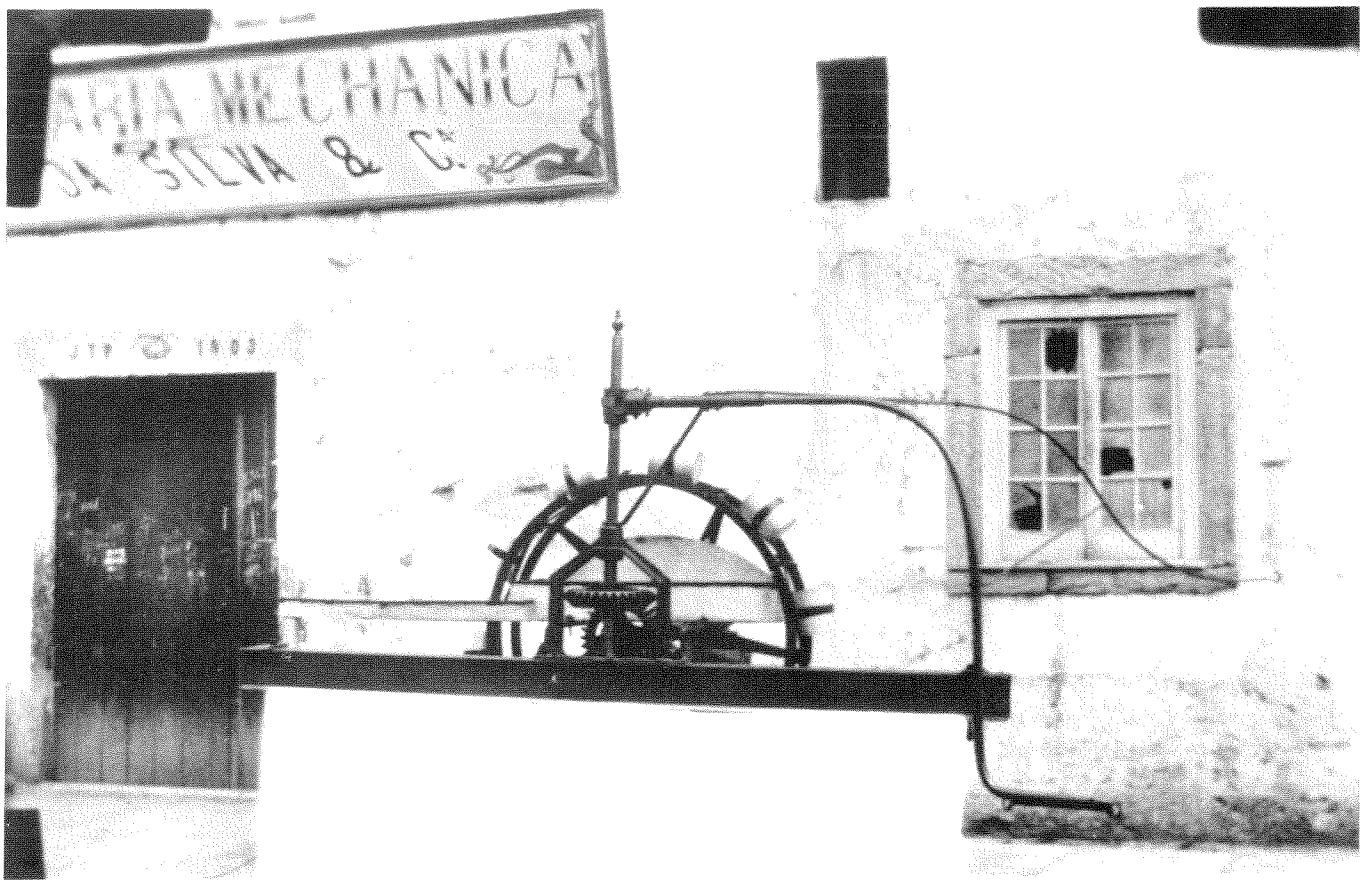

Fig. 7: The entrance to the Tomar Foundry's machine-room as it appeared soon after 1903. Part of the sign of Luiz da Silva and Co. is legible above the doorway. An irrigation wheel of a type still common in rural Portugal has just been completed and is awaiting despatch to the farm. (From photograph 58/67, Camara Municipal de Tomar)

Fig. 8: The casting-shed at Tomar as casting began on 10 May 1988. The rows of different mould-boxes are neatly laid out and in the back centre the workmen are filling the first ladle with molten iron from the blast-furnace.

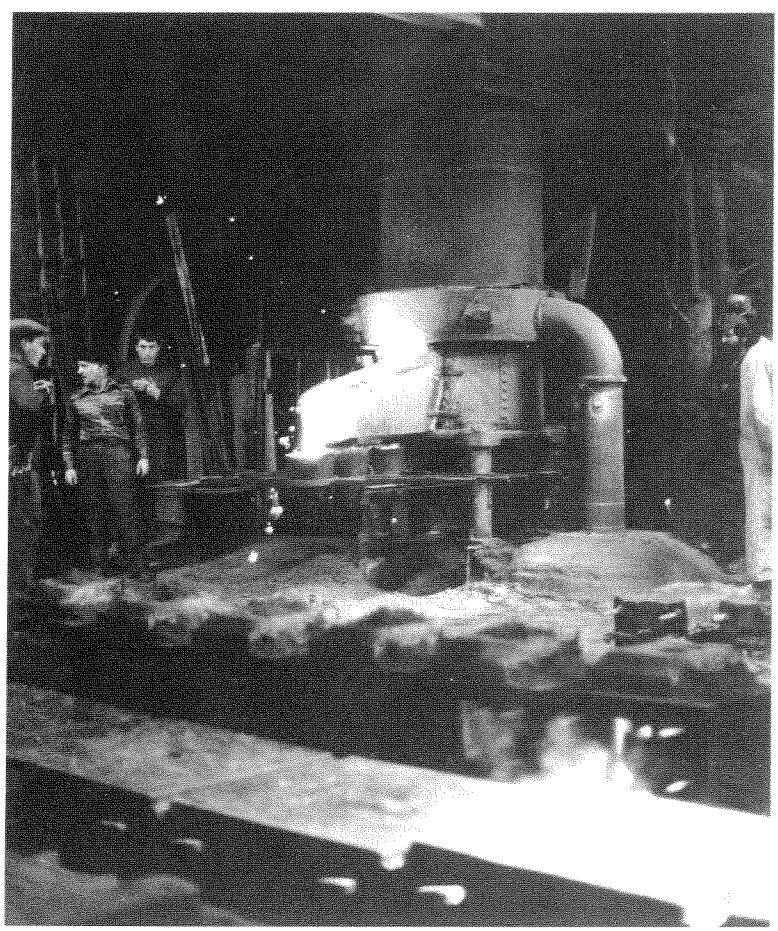

Fig. 9: The blast-furnace at Tomar. The cold-air blast comes under the floor and enters the furnace through the vertical pipe just to the right. The ladle is filling with molten metal while two others are ready on the rack. The foreman is directing operations from the extreme left.

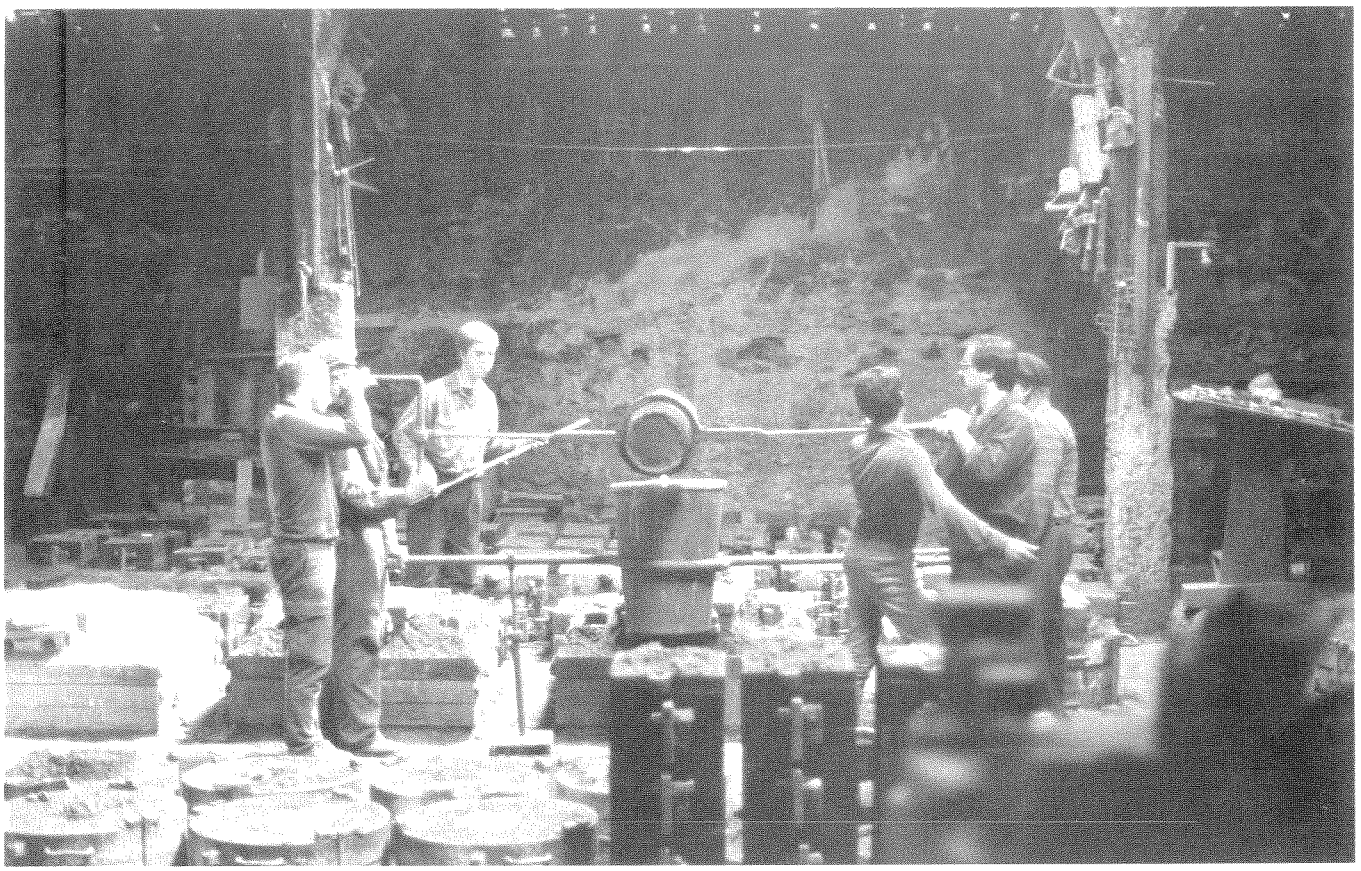

Fig. 10: Filling the large ladle, the 'shank', from a small ladle held at shoulder-height by five men. The forked handle on the left controls the degree of tilt, while the young apprentice beyond is ready to scrape away any unwanted slag floating on top of the hot metal. Five ladlesful are required to fill the shank.

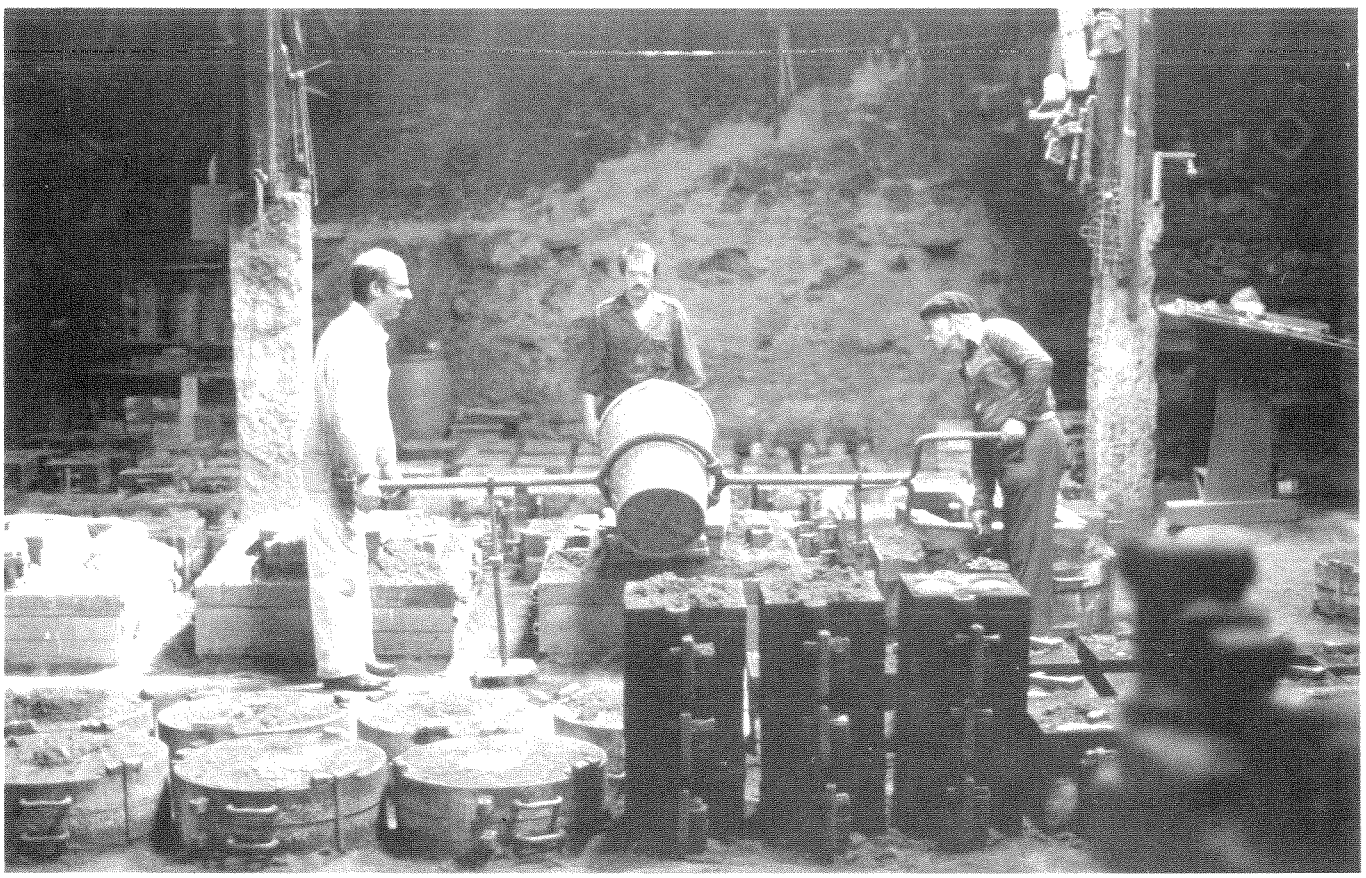

Fig. 11: Tilting the shank to fill one of the extra-large moulds. The angle of tilt is controlled by the forked handle on the right. Only two men are needed since the shank is securely pivoted on vertical holds.

Fig. 12: The last stage in emptying the shank at Tomar, with three men controlling the tilt and the apprentice scraping away fragments of slag from the molten metal.

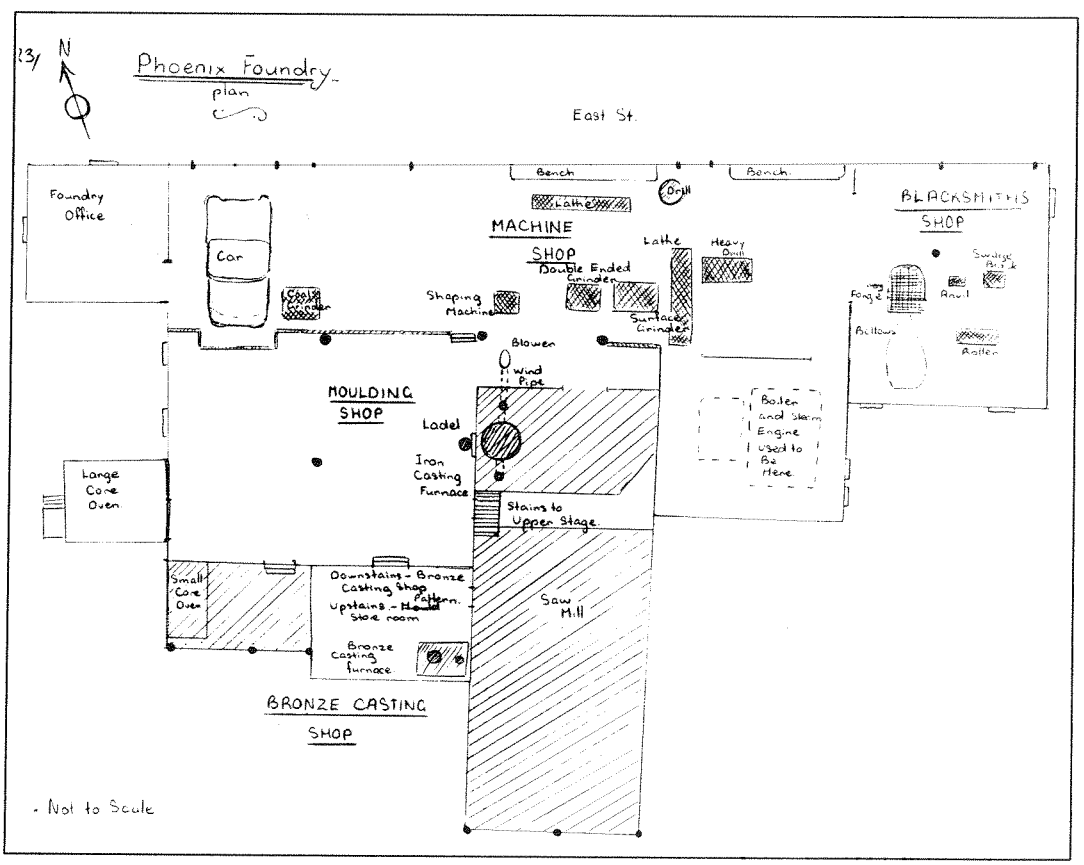

Fig. 13: Plan of the Phoenix foundry at Uralla, New South Wales, opened in 1898, as it was at the end of its life as a traditional foundry in 1975. (Reproduced by courtesy of M. Simpson from Barr 1975)

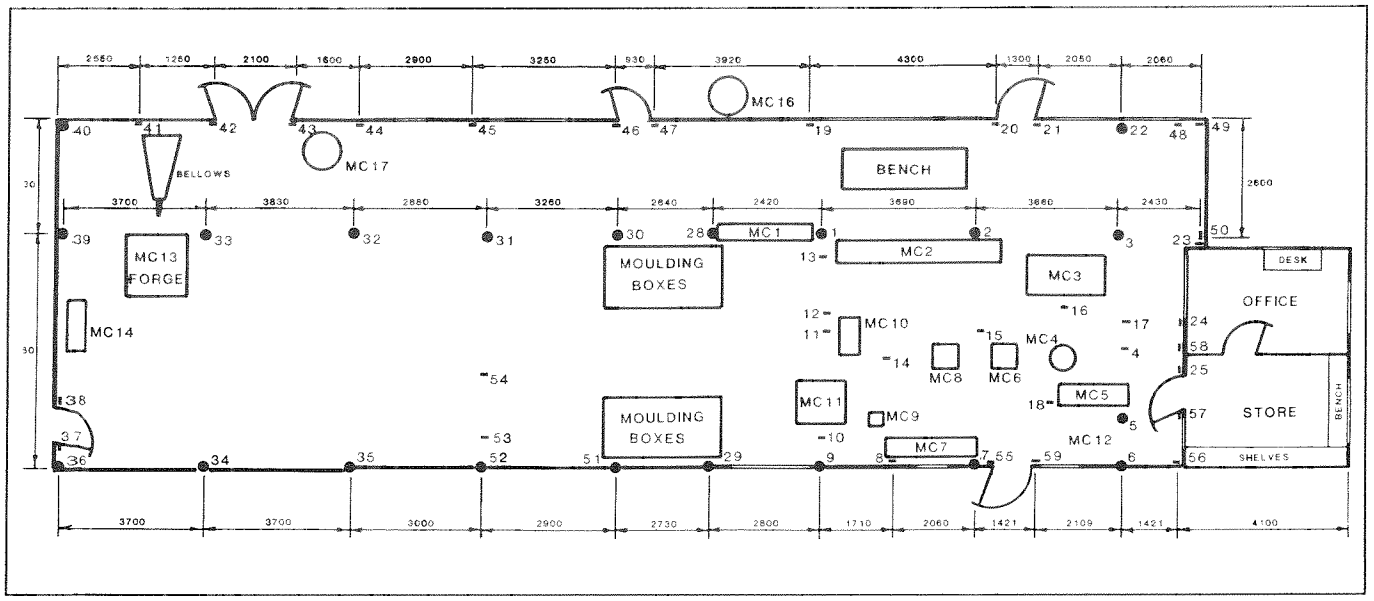

Fig. 14: Plan of Laycock's Foundry when still in situ at 108-110 Seymour Street, Bathurst, New South Wales. The blacksmith's shop of the 1880s had been extended in 1892 to include a machine-shop and foundry. In 1917 the position of the machine-shop and foundry was inverted to form the layout shown on this plan. (Reproduced by courtesy of J.W. Gibson from Gibson 1988: vol. 2, Appendix J2)

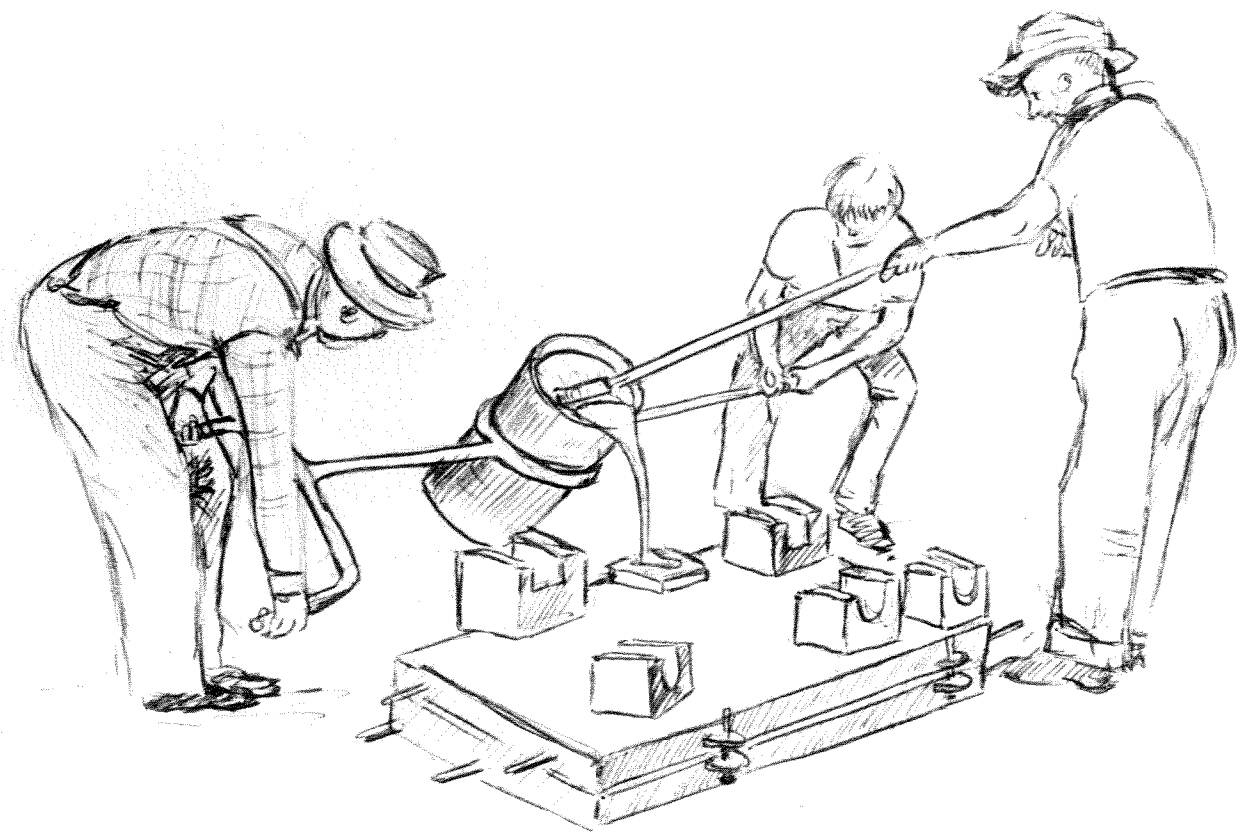

Fig. 15: Tilting molten iron from a ladle to fill a mould at Phoenix Foundry, Uralla, drawn from a photograph in 1975. (Reproduced by courtesy of M. Simpson from Barr 1975: Fig. 19) Pouring the molten iron into the mould from the two-man ladle. Weights hold down the top of the mould. A third man skims dirt from the surface so as not to allow dirt into the mould.

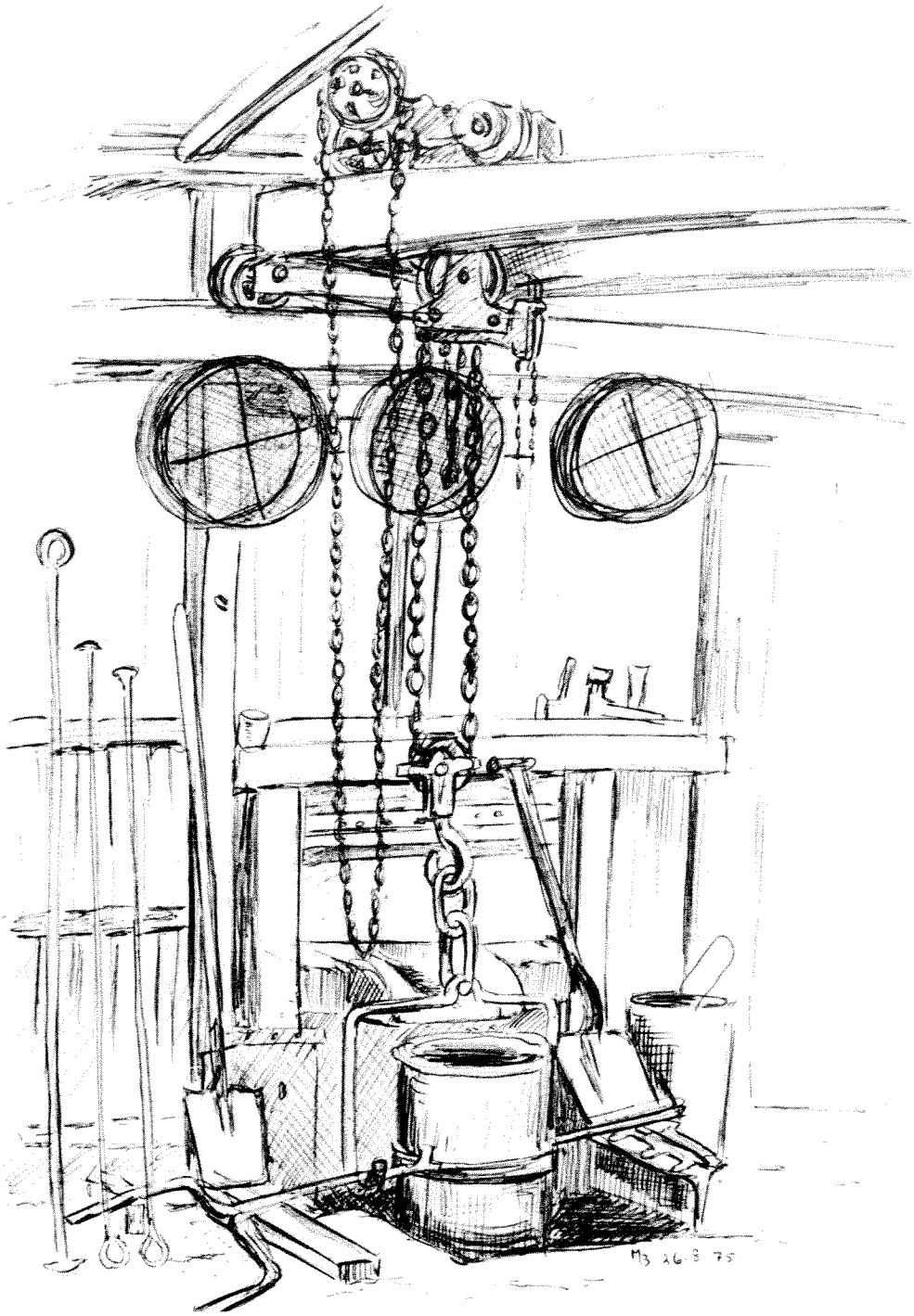

Fig. 16: The overhead crane for moving the large ladle over the casting-floor at Phoenix Foundry, Uralla. (Reproduced by courtesy of M. Simpson from Barr 1975: Fig. 2). The ladle holds 400 lbs of molten iron. Hammers are shown at left and sieves above.