Technology, the Division of Labor, and Workers’ Power in Brazil’s National Steel Company

by

Oliver Dinius
(University of Mississippi)

Prepared for Delivery at the

International Economic History Conference 2006

Helsinki, Finland,
August 24, 2006

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Oliver Dinius
Department of History
Bishop Hall
University of Mississippi
University, MS 38677
ph.: 662-915-3791
dinius@olemiss.edu
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By Oliver Dinius

This chapter analyzes the production process and the division of labor at Brazil’s Companhia Siderúrgica Nacional (CSN, =National Steel Company) to assess whether (and if yes, how) these technical characteristics afforded the company’s workers a exceptionally strong position in industrial relations. This question is relevant for the historian of 20th Brazil because the state-owned CSN was at the core of the country’s state-led industrialization drive from the 1940s to the 1970s: as the country’s only integrated steel mill, it was the domestic source for the steel to build Brazil’s high-rises, factory halls, and major bridges, and to domestically manufacture armaments, heavy machinery, and (so at least the plan) automobiles. The Brazilian state had committed so much actual and political capital to the CSN’s construction in the early 1940s that the company’s success became both a fiscal and a political imperative. The CSN’s official (nationalist) history presents it as an unmitigated success and an example of lack cooperation, but the documentary record indicates that the late 1950s and early 1960s witnessed increased workers’ power and intensifying conflict in industrial relations that was often resolved in the workers favor. This history diverges sharply from the general history of labor in Brazil in those years and would appear to require an industry-specific explanation.

There are at least three distinct approaches to describing and analyzing the division of labor in a large-scale industrial plant such as an integrated steel mill. One is to highlight the degree of specialization in the plant by describing employed machinery, work process, and skill profiles in summary statistics: the number, cost, and technical specifications of the machinery, the count of workers of a particular occupation, skill, and experience, and the quantity and cost of the products. This can capture some of the complexity of the division of labor. Then there is the description of the actual production process, the sequence of chemical and physical transformations of raw materials into the final product. To capture the full complexity at that level requires breaking the work process down into tasks performed by individual workers, or at the very least individual
machines. This sequential description of transformations highlights the diachronic division of labor among workers in the same department and between departments.

Still, even such a description in the greatest imaginable detail cannot capture one key aspect of work in any large-scale industrial plant: the synchronic division of labor. All departments in the mill – production, maintenance, and support – operated simultaneously and continuously supplied other departments with products and services that were not part of the main flow of the production of steel. The water treatment plant supplied water to the coke plant to spray the red-hot coke; the generating station supplied electricity to the rolling mills to power its engines; slag from the open-hearth furnaces went into the blast furnace loads; and the steel works used scrap from the rolling mills for the open-hearth furnace loads and coke oven gas to fire the heat - to name just a few examples for this departmental interdependence. There was a synchronic division of labor within departments, too; most employees depended on the cooperation of highly specialized colleagues in the department to perform their tasks. The most obvious example for such synchronic divisions of labor were the relationships between machine operators and maintenance personnel: if the machine was not properly maintained (above all lubricated), the operator could not even start to produce.

The synchronic division of labor, imposed by the technical characteristics of the production process, presented therefore the greatest challenge for the organization of work. Management aimed to balance the supply of intermediate products, inputs from support units, and services with the demand in the consuming departments in order to produce close to machine capacity throughout the entire mill. A slowdown in one, technically strategic department could affect several other departments, even induce a domino effect of shortages throughout the plant, and thereby undermine a fuller utilization of production capacities. Within departments, particular occupational groups or even individual workers could create temporary bottlenecks in the flow of supplies or the availability of services and thereby induce a slowdown for the entire unit. The analysis of the work process highlights the significance of this synchronic division of labor as a source of power for particular occupational group and individual workers on the shop floor. The German labor historian Thomas Welskopp uses the term “Störmacht” (disruptive power) to describe the ability of crews in American and German steel plants
The scholarly recognition that workers at this integrated steel mill possessed such Störmacht does not automatically mean, though, that they as individuals or as a collective were fully or even partially aware of it. The scarce records of the local metalworkers union contain no indication that it recognized this “strategic power”, to use John Womack, Jr.’s terms, or that it designed its approach to industrial relations with the CSN and the demands based on an specific assessment of that power for the whole plant, entire departments, or individual occupations. There are fundamentally two explanations for this seeming ignorance of strategic power in this integrated steel mill: (a) the workers and their union leaders were indeed not thinking about their ability to bargain in those terms, or (b) they were aware of it but thought it to be too important to commit to paper. An additional problem is that one would expect (b) to be the case if the workers and union leaders had a strong sense of “strategic power.” The historian of labor aiming to incorporate such considerations into her/his analysis would face a conundrum not unlike that faced by historians of intelligence operations: the most direct and incontrovertible evidence is least likely to be available! Womack’s exhaustive research on the history of the analysis of labor power demonstrates, however, that no union organizer, labor historian, or scholar of production processes has ever formalized the analysis of labor power in terms of workers’ “strategic positions.” Assuming a genuine lack of awareness of “strategic power” is just as speculative as assuming that workers and labor organizers had a keen sense of strategic power and shrouded it in complete secrecy. Most workers in strategic positions, certainly after some time on the job, must have developed an intuitive sense of their power, but that may they may only have used it opportunistically for limited (personal) gain in industrial conflicts. The core question is, then, whether union organizers and/or management at the CSN (and elsewhere) developed analytical tools or ‘formulas’ to assess or calculate strategic power.

Two examples from the CSN’s slabbing and blooming mill illustrate that management paid attention to the workers’ power to disrupt production. The occupational description for the ingot buggy operator (Operador da 1a Balança e Carro Lingote) stated that “he directly influences the process and can create a bottleneck in the
operation.” The hot saw buggy operator (Operador do Carro de Pontas da Tesoura à Quente), in contrast, could only cause major havoc if he failed to fulfill his duties over an extended period of time. “The removal of the deposits from the pits with pumps influences the process once the accumulation of deposits causes stoppages.” Importantly, both occupational descriptions emphasize the potential risks for the (production) ‘process’: the industrial engineers included these comments primarily to alert the supervisor on the shop floor to vulnerable points. Implicitly, though, it was also an assessment of the technically strategic power workers in these positions held. The CSN’s occupational descriptions as a whole do not provide the evidence, however, to conclude that the industrial engineering department assessed technically strategic power systematically. Then again, the occupational descriptions might not be the place to find evidence for such a systematic effort, since their content had to be approved by a union representative – at least in the case of the set from the late 1950s and early 1960s that I used most heavily to reconstruct the work process at the CSN. The records of the industrial security department would be a more likely source for an assessment of strategic power, but those files were not available to me for the case of the CSN.

What the historian can do is analyze an industry’s division of labor to identify strategic positions in the production process and thereby ‘map’ potential workers power. A full analysis of the diachronic and synchronic divisions of labor at the CSN would require a detailed description of the work process in all departments, a task that certainly beyond the scope of this paper – and maybe even beyond the scope of any historical study. One indication of the degree of differentiation in integrated steel mills is U.S. Steel’s efforts to classify its workforce in the 1950s: it produced no less than 25,000 occupational categories to cover 150,000 employees. The CSN was of course much smaller and significantly less complex. In 1951, its mill occupied about 9,000 workers, organized in 25 departments and classified in well over a thousand occupational categories. Still, a full description of the diachronic and synchronic division of labor for all production, support, and maintenance departments would itself be a book-length project.

Instead, the goal here is to illustrate the deep significance of the technologically imposed division of labor in (1) a general description of the technology and workforce of
this integrated steel mill and (2) a more specific analysis of the diachronic and synchronic division of labor for a selection of departments. The analysis of the blast furnace, the steel works, and selected rolling mills highlights the diachronic division within and between departments that are at the core of the production process in steel. Although the production departments that the laymen thinks of as characteristic for the steel industry, they actually employed altogether only about 40% of the permanent blue-collar workforce at the CSN – a figure that includes the coke plant and all rolling mills. The remaining 60% of the blue-collar workforce was employed in support and maintenance (Table 6.1).

The production of steel in an integrated mill consumed large quantities of electricity, water, and steam, depended on internal transport to move intermediate products, and required continuous maintenance of the heavy equipment. The mill was “integrated” beyond the vertical integration of the metallurgical production to a horizontal integration of services (transport, maintenance) and to a vertical integration of non-mineral inputs (electricity, water). Cost estimates for manufacturing expense for the production departments all list power, steam and water, fuel, services, transport, and maintenance as significant operating costs, and the rolling mills also include expenses for rolls from the foundry and the roll shop. Often, these intersecting levels of integration saw triangular relations between departments. The blast furnace, to cite just one example, supplied gas to the power station, which burnt it to generate the electricity for the rolling mills.

These connections enhanced the vulnerability of the entire operation to disruptions in individual departments. Some potential bottlenecks were of greater concern than others. Raw material and intermediate products could be stored to ensure a supply at least for hours, if not days: the coke plant kept coal in the oven bins; the blast furnace maintained a stock of ore, coke, and minerals; the steel works stored pig iron as ingots or in the hot metal mixer; the rolling mills stored ingots in the soaking pits and slabs and blooms in the storage yards. Large gas tanks ensured a supply for the firing of the coke plant, the blast furnace, and the open-hearth furnaces. The foundry could build up a stock of rolls and spare parts to supply the rolling mills. Storage was not an option, however, for most of the support departments. It was technically not feasible to maintain a reserve of steam or electrical power, and water consumption was too great to make decentralized tanks an
option. Maintenance and transport services were by definition not storable, although foresight in the planning of deliveries and scheduled maintenance could reduce the dependence on their uninterrupted availability. Management paid particularly close attention to the organization of work in these departments, because trouble there could disrupt production fast and in many places at once.

The two main examples chosen here to illustrate the division of labor within such support departments, and between them and production departments, are the foundry and the Departamento de Energia (DEN). The discussion of the foundry focuses on the work of making molds for the iron and steel rolls used to flatten the steel in the production of the rolling mills. Many highly skilled craftsmen and experienced operators worked together to make these molds, which highlights the synchronic division of labor internally – but also the cooperation and with production departments (and a certain dependence of the latter on the former). The DEN, which supplied the entire mill with water, steam, and electrical power, serves as the prime example for a department that is outside the main flow of production, but nevertheless technically strategic because of its interconnections with almost all other departments in production, support, and maintenance. There is no making steel in a modern integrated mill without a constant supply of large quantities of electrical power. Internal transport, roll repair, the refractory department, and electrical and mechanical maintenance receive a brief treatment at the end of the paper to suggest the parameters for a future, more comprehensive analysis of the technically imposed synchronic division of labor in the integrated steel mill.

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Technical Characteristics and the Division of Labor

The CSN’s equipment was up to the technological standard of the time. The U.S. engineering firm Arthur McKee & Co. had been in charge of the mill’s technical design. The parameters were clear: it was to be an integrated plant, with an initial annual capacity for 300,000 tons of steel ingots, and equipped with the machinery to roll rails and heavy beams as well as wire or tinfoil. The companies selected to supply the major pieces of equipment for the mill all enjoyed excellent reputations in the respective field. Koppers & Co. build the coke plant: its ovens were the industry standard, in large part because of its sophisticated byproducts plants. The CSN installed a blast furnace by Arthur McKee &
Co.’s, then still the leading technical design, and open-hearth furnaces for the steelworks from the British-American engineering firm Brassert. For the of rolling equipment, the CSN split its orders between the two leading manufacturers: MESTA and U.S. Steel. The former supplied the slabbing and blooming mill and the hot-rolling mill, and the latter both the plate mill and the cold-rolling mill. Morgan supplied the rail and structural mill, and Wean both the tinning and the galvanizing line.\(^\text{10}\) The CSN had the original mill designed in a way that left space for a two-step expansion of the facilities to increase the capacity of the plant to one million tons of steel ingots annually. Thereby, the original technical design shaped the successive expansions in the 1950s and 1960s. The original equipment went into production between 1946 and 1949.\(^\text{11}\)

The CSN supplied domestic consumers with a broad spectrum of products: in 1951, it made rails and accessories (85,000t), cold rolled sheets (65,000t), steel plate (33,000t), hot dipped tin plate (33,000t), structural (23,000t), hot rolled sheets (18,000t), hot rolled coils (16,000t), re-rolling bars (16,000t), and galvanized sheets (12,000t).\(^\text{12}\) These figures do not represent full machine capacity, however, because of the realities of the small market and the plant layout. To be able to accommodate this diversity of products in its schedule, the CSN had opted for discontinuous processes. It separated the hot rolling mill from the roughing mill, for example, to be able to continue operating one whenever roll changes were needed in the other. The flexible arrangement came at a cost, however: production was smaller and productivity lower than in large mills in the United States that used the identical equipment in a continuous process.\(^\text{13}\) The overall layout of the plant created additional inefficiencies; the CSN had to place the blast furnace and steel works side by side, rather than both in line with the rolling mill, because the mill location did not provide sufficient space. Such space-saving measures made transport of intermediate products between departments more complicated, slower, and more costly, a problem that was further aggravated with the mill expansions in the 1950s.
Illustration 6.1 represents the basic production process at the Volta Redonda steel mill as of the early 1950s. There was no fundamental change in this diachronic division of labor until the late 1960s. The implementation of *Plano B* (1950-53) and *Plano C* (1956-58) increased production capacities but did not introduce equipment that altered the overall organization of the production process. *Plano B* doubled the number of coke ovens, added a second blast furnace, added open-hearth furnaces, and enhanced the capacities of the secondary rolling mills. The one new technology introduced was the electrolytic tinning line installed in the cold rolling department. It operated in addition to the hot dip tinning installations to increase tin plate capacity. Under *Plano C*, the company added more coke ovens, two more open-hearth furnaces, and augmented its facilities for producing flat rolled products. Technologically new was only the sintering plant for the blast furnace department. It allowed the CSN to ‘pelletize’ iron ore with fine coke dust, thus increasing the efficiency and throughput of the furnace. Both plant
expansions increased the number of workers, but created few new types of jobs.\textsuperscript{15} The first dramatic change to the production process was the introduction of the basic oxygen furnaces in the 1960s, which reduced the time for a ‘heat’ of steel from 8-10 hours to 15-20 minutes.

The CSN’s created a complex administrative structure to organize production. The \textit{Diretoria Industrial} (DI) oversaw 25 departments, each subdivided into several divisions with subordinate sections.\textsuperscript{16} Department size could vary greatly: the planning department, one of the smallest, had only 35 employees, while mechanical maintenance had almost 1,500 men on the payroll. Most departments were subordinate to groups (\textit{grupos}). The largest of these groups, metallurgy, rolling, and maintenance, were subordinate to the \textit{Superintendência de Operação} (SO), which also included the energy department, the roll department, and the division for telecommunications. The departments for research and inspection, planning, and administration reported directly to the DI; so did the groups for supplies, general services, and industrial engineering (\textit{Engenharia Industrial}).\textsuperscript{17}

Table 6.1 illustrates the skill profile of the workforce. Maintenance and support departments, not production, had the highest concentration of skilled workers.
Table 6.1: Skill Profile of CSN Workforce (1951)\(^{18}\)

<table>
<thead>
<tr>
<th>Employees</th>
<th>Skilled &amp; Semi-Skilled</th>
<th>Unskilled</th>
<th>Clerical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron &amp; Steel</td>
<td>799</td>
<td>525 (65%)</td>
<td>274 (34%)</td>
</tr>
<tr>
<td>Rolling &amp; Finishing</td>
<td>1775</td>
<td>992 (56%)</td>
<td>767 (43%)</td>
</tr>
<tr>
<td>Production (Total)</td>
<td>2574</td>
<td>1517 (59%)</td>
<td>1041 (40%)</td>
</tr>
<tr>
<td>Elect. Maintenance</td>
<td>411</td>
<td>388 (94%)</td>
<td>14 (4%)</td>
</tr>
<tr>
<td>Mech. Maintenance</td>
<td>1502</td>
<td>1310 (88%)</td>
<td>150 (10%)</td>
</tr>
<tr>
<td>Maintenance (Total)</td>
<td>1913</td>
<td>1698 (90%)</td>
<td>164 (8%)</td>
</tr>
<tr>
<td>Foundry</td>
<td>508</td>
<td>422 (83%)</td>
<td>81 (16%)</td>
</tr>
<tr>
<td>Energy &amp; Communic.</td>
<td>260</td>
<td>223 (86%)</td>
<td>34 (13%)</td>
</tr>
<tr>
<td>Internal Transport</td>
<td>773</td>
<td>568 (73%)</td>
<td>193 (26%)</td>
</tr>
<tr>
<td>Inspection &amp; Planning</td>
<td>336</td>
<td>273 (81%)</td>
<td>46 (14%)</td>
</tr>
<tr>
<td>Support (Total)</td>
<td>1877</td>
<td>1486 (79%)</td>
<td>354 (19%)</td>
</tr>
<tr>
<td>Supplies</td>
<td>477</td>
<td>58 (12%)</td>
<td>318 (67%)</td>
</tr>
<tr>
<td>MILL (Subtotal)</td>
<td>6861</td>
<td>4750 (69%)</td>
<td>1877 (28%)</td>
</tr>
<tr>
<td>Construction</td>
<td>399</td>
<td>213 (54%)</td>
<td>180 (45%)</td>
</tr>
<tr>
<td>Installations</td>
<td>187</td>
<td>110 (49%)</td>
<td>7 (3%)</td>
</tr>
<tr>
<td>City Services</td>
<td>115</td>
<td>73 (64%)</td>
<td>41 (35%)</td>
</tr>
<tr>
<td>Building Services</td>
<td>701</td>
<td>396 (56%)</td>
<td>228 (32%)</td>
</tr>
<tr>
<td>CSN (Total)(^{19})</td>
<td>7562</td>
<td>5146 (68%)</td>
<td>2105 (28%)</td>
</tr>
</tbody>
</table>

The three sectors employed roughly equal numbers of workers, but the share of unskilled laborers in maintenance (8%) and support (19%) was much lower than in production (40%). In fact, none of the production departments (coke plant, blast furnace, steel works, rolling mills) had a greater share of skilled and semi-skilled labor than any maintenance or support departments. A high concentration of skilled workers points to a strategic position in the departmental division of labor, although skill is not a direct measure for the technically strategic position at the level of occupational categories or individual workers.

The conditions of work in steel were very different from most manufacturing industries. The rhythm of work in the mill was demanding: it operated all year, seven
days a week, 24 hours a day. Production crews and the majority of employees in maintenance and support worked in three-shifts. Relatively few production workers came into direct physical contact with the product in the work process, and those were in their majority unskilled laborers who cleaned, packaged, and loaded the finished steel. Most other workers effected physical or chemical transformations of the product employing extreme heat and heavy machinery. Because of the size and complexity of the mill, production required a great deal of planning: the DPP (*Departamento de Planejamento de Produção*) established schedules that aimed to maximize production and to minimize idle equipment time for all departments. Communication with the DPP and between departments was crucially important for department heads, engineers, and some of the foremen.20

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**Production: From Iron Ore to Hot-Rolled Coils**

The transformation of coke, iron ore, and fluxes into pig iron occurred in the blast furnace. The CSN originally operated only one blast furnace, then added a second under the *Plano B* in the early 1950s, and subsequently expanded the first for larger loads. The larryman charged the blast furnace with the required mixture of coke, crushed iron ore, and fluxes, and he sometimes added small quantities of iron and steel scrap. He relied on the crews at the raw material yards and the coke plant to keep the storage bins filled. Each trip, he loaded the scale car with a different material, weighed it, and charged the load through a chute to the skip hoist. He operated the skip system to move the materials into a silo on top of the furnace, and once the mixture of materials was right, he operated pneumatic controls to charge the load from the silo into the furnace.21 The burning coke provided the heat for the smelting, a process accelerated by hot air blown into the furnace from tuyeres in the lower walls. The coke reduced the ore to liquid pig iron that settled at the bottom of the furnace, and the fluxes reacted with impurities in the ore to form slag that floated on top of the molten iron.

The cast house crew under the supervision of the blower foreman tapped the furnace four times per shift, alternating between slag and pig iron casts. The blast-furnace keeper opened the furnace-pouring hole by hammering a steel rod into the clay plug.22 The molten iron ran off through canals, lined with refractory material, into large pig iron
ladles on railcars. The cinder snapper performed the tapping operation for the slag and adjusted gates, both for pig iron and slag casts, to redirect the flow to empty ladles whenever necessary. Between casts, the cinder snapper and several helpers prepared the casts, setting gates, lining spouts, lining canals with refractory brick and clay, and cleaning the ladles. The engineer of the pig iron train delivered the ladles with the molten iron either to the pig machine for casting ingots or directly to the steel works. The engineer of the slag train moved it to a dump area, where the cinder dumper used a hydraulic system powered by steam from the locomotive to tilt the ladles and dump the slag.

Making steel from pig iron required oxidizing the impurities in the pig iron in order to reduce brittleness and to create a more malleable and durable material. The CSN operated eight 200t open-hearth furnaces, four on each charging floor. The mixer craneman hoisted the ladles with molten pig iron off the transfer cars and emptied them, assisted by the mixer crew, into the hot metal mixer. Only occasionally would the foreman request the craneman to charge the open hearth directly from the transfer ladles. The liquid iron commonly went into the mixer, and the mixer operator kept the temperature within specifications by adjusting gas flow to the heating system. Whenever an open-hearth furnace was due to be charged, the mixer operator worked with his helper and the craneman to pour iron from the mixer into ladles on transfer cars. A locomotive pushed the ladle car from the mixer to the furnace, where a craneman lifted the ladle, tilted it, and poured the molten iron over a spout into the furnace. In the furnace, it mixed with the solid charge - scrap, ferroalloys, limestone, dolomite, and iron ore – that the charging machine operator had prepared from bins on the charging floor. Burning oil generated the flames that surged over the charge in the open-hearth to drive the chemical reactions that removed the impurities and separated the slag. During the ‘heat,’ which took between eight and eleven hours, helpers constantly monitored the furnace temperature and provided the laboratory with samples to analyze the chemical composition of the load. The furnace foreman responded with adjustments in the firing or the addition of materials to improve the mix whenever the samples did not meet specifications.

The furnace foreman informed the melter foreman when the load was ready for tapping. The casting floor (ala da corrida) had been prepared during the heat; the
furnacemen lined the canals and the tapping spouts with refractory material, and the ladle craneman positioned the steel ladle on the furnace ladle stand, where a crew of castingmen replaced the ladle’s stopper and the stopper rigging. Another crew, assisted by a craneman, set and fixed the ingot molds on flatbed cars that were then moved to the pouring platform. The melter foreman used a jet-tapper, a small lance with an explosive charge, to open the tapping hole for the liquid steel to run off into the ladle. The slag could be tapped before the steel cast, or it was siphoned off the top of the full steel ladle into a separate slag ladle.\textsuperscript{27} A craneman hoisted the full steel ladle and positioned it over the mold cars. The first castingman, from the pouring platform, directed the craneman to position the ladle over each successive mold and operated the stopper to open and close the nozzle to fill it with steel to the desired level. The first castingman’s crew performed work on the mold as needed: applying additions, covering the mold top, or cooling the entire mold down.\textsuperscript{28}

Once the molds had cooled down enough for the steel to solidify, an engine moved the mold cars to the stripper area. The stripper operator craneman used tongues to lift the mold off the steel ingots; if the ingot was stuck in the mold, he moved them to a designated area to loosen them by dropping them in controlled fashion. The empty molds went back onto railcars and to the mold yard, while the steel ingots, or billets, were moved to the rolling mills on ingot buggies.\textsuperscript{29}

The first rolling of the ingots occurred in the slabbing and blooming mill. A craneman lifted the ingots off the buggies and placed them in soaking pits for reheating. The heater controlled the burners, fueled with a mixture of furnace gas and coke oven gas, to ensure that the ingots were hot and soft enough for rolling, but did not liquefy.\textsuperscript{30} Once the ingot was ready, the pit craneman hoisted it onto a buggy, while another crane held the pit cover. The buggy operator moved the ingot to the slabbing and blooming mill, where he docked the buggy and unloaded the ingot onto the first roll table. He weighed the ingot, repositioned it with the turner, if necessary, and operated controls to move the ingot to the blooming and slabbing mill approach table.\textsuperscript{31}

The CSN’s two-high reversing mill, powered by a 6,000 HP electrical engine, had a high-lift of 54 inches suitable to roll a wide range of slabs, blooms and billets. A team of two mill operators worked to execute the DPP’s production schedule. For each run, the
schedule specified the required metallurgical characteristics of the incoming ingots and established specifications for the rolled product. Commonly, the product had to conform to one of 80 standard specifications (medidas), but occasionally the schedule called for different shapes for custom-made products. The two operators, constantly coordinating their work, used levers and pedals to control the position and the speed of the cylinders of the reversing mill to produce the desired shape. They usually followed a pre-established routine of passes, but had to be prepared to recalculate the dimensions and make adjustments. Seated in an air-conditioned cabin above the approach table, they visually monitored the physical characteristics of the ingot throughout the roughing process. The work required high levels of attention, and to provide some relief, the operators regularly switched between main and auxiliary controls, respectively. The foreman took over the duties of one of the operators during scheduled breaks.32

The roughed slabs and blooms moved on roller tables from the blooming and slabbing mill to the crop shear, lined up with the mill about 100 to 200 ft apart. The shearman operated the hydraulic press to cut the sections to the specified lengths, gave the hotbed stamper time to mark them, and then worked with the second weighman to move them to the second scale. Once the slabs and blooms were weighed and recorded, a craneman moved them to the storage yards for cooling. The scarfers (escarfadores) used oxy-acetylene torches to burn out surface defects on slabs to prepare them for the next rolling sequence. Slabs and blooms that failed to pass the metallurgical inspection went back to the steel works as scrap. Stockers color-marked the good slabs and blooms by steel grade (carbon content) and final use and guided the yard cranemen as he stored them by shape and order in the production schedule. To facilitate the transfer, the storage yard crews stocked the blooms near the rail and structural mill and the slabs near the entry table of the hot rolling mill.33

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All rolling of slabs into flat-rolled products started at the plate mill. It served both as finishing stand for steel plate and as roughing stand for hot strip. In the early 1950s, the plate mill had only one stand, a 36” and 49” by 72” 4-high reversing rougher driven directly by a 5,000 HP motor. It was lined up with the slabbing and blooming mill to minimize the distances for slab transfers.34
A craneman moved the scarfed slabs from the storage yards to the charging elevator *(desempilhadora)* or directly onto the reheating furnace’s entry table. Pushed onto rollers, the slabs moved through the furnace at constant speed. The slab heater operated controls to adjust the air, gas, and oil flow depending on slab size and steel grade, and he monitored the heating process for unusual conditions. He knew from experience when the flames were too large or too small, when to use emergency procedures for the temperamental oil heating systems, and when to shut the furnace for cleaning or repairs. The heater also rejected improperly heated slabs and sent them back to the storage yard.\(^{35}\) Properly heated slabs moved directly from the furnace exit to the plate mill approach table.

The operation of the reversing rougher was similar to the slabbing and blooming mill. The operator controlled the position of the cylinders and their speed, the water-based cooling system, and the reversing rollers on approach and exit tables. The plate passed back and forth between two work rolls in the middle, each supported and protected against bending by a larger back-up roll. The operator adjusted the roll draft and the height of the tilting tables as the plate became thinner and thinner with each pass. Simultaneously, the edger operator straightened the plate’s edges. After the second and fourth passes, respectively, he activated a pair of vertical roles at the entrance table and moved them close enough together to give the section the desired width.\(^{36}\) Once the plate had the desired thickness and width, the mill operator moved it to a shear for the shear operator to cut it to the specified length. The foreman decided whether the plate had the quality to be used in hot rolling and instructed the shear operator to separate all other plate, depending on the quality either for delivery to customers or to be scrapped. The shear operator moved the separated plate onto the hotbed for gradual cooling and then over the transfer runout table to the finishing section. The hot leveler operator straightened uneven or bent plate, before it was cut again in the second shear, and then stacked and prepared for shipping by a crew of laborers.\(^{37}\)

Quality plate destined for hot rolling moved on roller tables straight from the first shear to the hot-rolling train. Its four 4-high stands, each driven by a 2,500 HP engine, had 22.5” work rolls, 46” back-up rolls, and a rolling width of 54”. The operators, one for each stand, prepared the run by setting the roll draft. They monitored the stand’s
temperature, speed and cooling system during the run, always ready to respond to problems and make adjustments. As it passed through the successive stands, the steel strip became thinner and thinner, and thus passed faster and faster, which required a precise coordination of the stands’ speed settings to insure uniform pull. The hot-strip mill foreman calculated the reduction percentages and the speeds for all four stands, set the control screws to those values, and informed the speed operator of the chosen settings. The strip, now up to a quarter mile long, passed under a series of cooling water sprayers as it shot out of the last finishing stand onto the run-out table. Cooling the strip evenly was crucial, because that gave it the right metallurgical properties for further processing in the cold-reducing mill.38

The cooled strip was either sheared to make hot-rolled flat sheet or coiled to make hot-rolled coils. For flat sheets, the operator sheared the strip, stacked the sheet in the stacking machine, and passed it on to the finishing section. The flat sheet finishing crews operated two levelers and two shears to correct distortions that occurred during rolling, cooling, or shearing on the hot rolling mill.39 Coiling the hot-rolled strip was a delicate operation. The coiler operator used electrical hand controls to start, stop and regulate the speed of the rollers that conveyed the strip and of the coiler. It was crucial to receive the strip at mill speed, to coil it tightly without excessive tension, and to discharge the coil quickly and without damage onto the conveyers that moved it to the storage area.40 Hot-rolled coils could be shipped directly to customers, but more commonly, they were processed further into cold-rolled sheet.

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**The Foundry: Making the Mold for a Roll**

Production at the CSN depended on an in-house supply of parts. Most important in that respect was the foundry, the Departamento de Fundição (DFU), which custom-made the rolls for several of the rolling mills. The DFU employed more than 500 men, which made it the third largest department. Much of its production were castings needed in operation, such as ingot molds and stools, pig machine molds, and smaller items such as crane collector shoes, railway brake shoes, babbitt and bronze bearings, and pieces needed in maintenance and repair. In the average month, the foundry produced 3,143 brake shoes and 21,824 iron and steel pieces, and it also cast nine ingot molds and fifteen
ingot stools for use in the steel works. In emergency situations, the foundry could cast highly specialized steel shapes, such as die-castings, special alloys, large rolls, and blast furnace big bells, but Freyn Engineering’s expansion report in the early 1950s recommended that it not produce those items in regular operations. The foundry also produced much of its own casting equipment, such as flask parts, patterns, and prints.

It was the foundry’s highest technical distinction that it could cast iron rolls for the CSN’s plate mill, hot rolling mill, and the rail and structural mills. According to the industry bible, The Making, Shaping, and Treating of Steel, “[t]he manufacture of rolls for rolling mills” was “one of the most highly specialized phases of the iron and steel industry.” This was “one of the few remaining phases in which the manufacturer develops and applies its own chemical and metallurgical specifications to make a product in accord with the individual requirements of a particular rolling mill,” and foundries employed “expert technicians who devote[d] all of their attention to the development and practice of this art, to the planning and prescribing of each step in the manufacture, and to directing highly skilled personnel.” Rolls were cast from steel, steel-alloys, or iron-alloys. The thinner the steel, the harder and smaller the rolls had to be; grades differed even for the roughing, intermediate, and finishing stands of the same mill. They were custom-made for the plant in a process that combined artisanry with the use of mechanized equipment. The production of each roll required a series of carefully executed, time-consuming steps. In 1962, the foundry disposed of fourteen sets of flasks for molding rolls, but still only produced three rolls per working day on average.

The high level of specialization of the foundry’s employees and the complex division of labor required thorough production planning and constant communication between the pattern shop (oficina de moldes), pattern and core box storage, sand mill, molding area, furnace section, and finishing area. Work with blueprints, meticulous record-keeping on finished patterns, and case-by-case requests for particular sand mixtures placed a high premium on an efficient bureaucracy. The foundry’s “office for planning and sketches” (delineamento) established the production schedules and coordinated the different sub-units. The planners (delineadores) depended heavily on recorders (anotadores) to manage the paper trail for the movement of pieces and equipment and on production
controllers (*controladores de produção*) to monitor the progress of work and the completion of tasks.\textsuperscript{45}

“The construction of a pattern” was, according to *The Making, Shaping, and Treating of Steel*, “perhaps the most important single factor in the production of a casting.”\textsuperscript{46} The pattern makers (*modeladores*) were among the most highly skilled craftsmen in the mill, and the quality of their patterns for rolls ultimately determined whether the rolling mill operator could produce high-quality steel plate and sheet. The pattern maker first had to interpret and analyze the blue print for the roll to decide what grade, type, and size of lumber was best suited to make the pattern. He used trade mathematics, handbooks, and shop formulae to calculate the dimensions of the pattern, always considering the casting material and the scheduled heat treatment, and making allowance for metal shrinkage in the cooling process. He decided whether the design required the use of cores (*macho*), prefabricated castings made of sand that were mounted on the main mold to create ribs, bolt holes, or hollowed out sections. The pattern maker designed the pattern and the core boxes (*caixa de machos*) in accordance with established practices of pattern making and molding. He also did the layout work required for irregular or complex shapes.

For the manufacture of patterns and core boxes, the pattern maker operated wood working machinery and used a variety of hand tools for forming the material. He commonly used his own set of tools, although the CSN lent him the more expensive and less commonly used special tools. The pattern maker finished and assembled the component parts of the pattern using hand tools, glue, nails, and dowels. He strengthened the pattern’s stress points to protect it against warpage, smoothed it, reduced it to the final dimensions, and finished the job by applying shellac to prevent the absorption of moisture.\textsuperscript{47} Instead of a full-size model, patterns for rolls often took the form of a sweep (*chapelona*), a flat board carved on one edge to conform to the longitudinal contour of the roll, with provision on the other edge for fastening the sweep securely to a spindle or axle.\textsuperscript{48} By 1962, the CSN’s pattern makers made between 60 and 90 new patterns each month, repaired or modified a fluctuating number of old patterns, and also produced about 2,800 casting rods (*rôdos de vazamento*) and more than 600 small and 300 large platforms (*estrados*). The head of the pattern shop established the deadlines for patterns of normal or particular urgency (“U”), but had to meet the deadlines imposed by the
office for planning and sketches (delineamento) for projects of higher (“UU”) or highest urgency (“UUU”).

The pattern storage foreman, also the pattern checker (afedorid de modêlos), catalogued any new pattern according to type and used materials, and his crew stored it in a location recorded on a pattern file. To keep the more than 9,500 patterns in the recorded place and correctly labeled was crucial to avoid a waste of time, or worse, the fitting of molds that did not meet the drawing’s specifications. The planning office provided the storage foreman with a list of the patterns that were to be used in production the following week. He pulled out the file for the requested patterns, approximately 180 each week, and sent his crew to retrieve them from storage. They were signed out to the helpers sent from the molding section. If the storage crew discovered that a pattern was defective, either upon delivery or in the storage, the pattern checker filled out a report and sent the piece to the pattern shop for repairs. The CSN often adapted old patterns to fit a new design because it was quicker and less costly than making a new one. The file card always stayed with the pattern while it was out of storage to allow for the annotation of damage or modifications before the storage foreman signed the pattern back in.

The sand mill used a range of materials for its mixtures: lake sand, green bond, fire clay, corn flour, silicon flour, brass sand, to name just a few, and it also utilized old sand molding from the blast furnace casting house. It continuously supplied the molding and core making shops with common sand mixtures and provided less common ones upon request. The sand mill operators, each responsible for a 750kg mixer, filled moveable overhead bins with primary materials from the stationary main bins and loaded them into the mixer. The operator assessed whether the mixture was sufficiently moist and porous, and, if necessary, added water. The sand mill lab took regular samples to monitor the quality of the mixtures. The sand mill operators delivered the finished mixtures to the shops on belt conveyors (correia transportadora).

Core makers (macheiros) and molders (moldadores), the men who used the sand, performed some of the most skilled work in the mill. They had intimate knowledge of reinforcing methods, the physical properties of various sand mixtures, and the adequate venting of cores, and they used a variety of machines and the tools of their trade.
complex designs, the core makers had to complete their work before the molders could even begin work on the main mold.

The core maker first had to retrieve the components of the wooden core boxes from the pattern shop or from storage and assemble them with fittings and clamps.\textsuperscript{53} Based on the drawings, he decided whether the core required reinforcements made from wire or iron rods. The core maker used hand tools and metalworking machinery to custom-make needed reinforcements, sometimes with the help of a welder. He cleaned the box, put the reinforcements into place, and firmly packed the box with a prepared sand mixture. To insure that gases could escape during the casting, he often inserted wax-wire that melted away in the heat to form small air canals. Alternatively, he added substances less dense than sand to the body of the core, such as coke or sawdust (\textit{palha de serragem}), to allow for gas flow during the casting. After swiping off excess sand, the core maker removed the box, patched any breaks, and applied core wash to seal the sand and protect the surface against penetration. He moved the core to the drying oven, either by buggy or with the help of a crane, and charged the oven. He also discharged the oven and assembled the dried cores that had several parts, which often required filling cracks and seams with silica paste. Applying a graphite coating to the entire core surface served as finishing.\textsuperscript{54}

The molders (\textit{moldadores}) selected suitable flasks (\textit{caixas de moldagem}) for the main mold, based on the roll design.\textsuperscript{55} Flasks were “rolled-steel, cast-steel, or wooden frames used to hold the sand around the pattern,” manufactured in-house in standardized sizes, and they usually fit a spectrum of patterns.\textsuperscript{56} For rolls, the foundry employed two main casting techniques that corresponded to different work routines for the molders. The flasks for chill-iron rolls (\textit{cilindro de ferro coquilhada}), used on the plate and hot-rolling mills, consisted of three sections; there was a heavy-walled cast-iron cylinder, the ‘chill,’ to form the body of the roll, and a pair of flasks on each end for sand molds to cast the wobblers and necks.\textsuperscript{57} The molder made sure that the right sand mixture was in stock and directed the craneman to position the pattern and the first flask. He shoveled the sand into the flask, spread it with his hands, and then rammed it in with a small pneumatic hammer. Then he signaled the craneman to deliver the second flask, used clamps and wedges (\textit{cunhas batidas}) to attach it to the first, packed the sand in, and placed a second pattern
for the tedge (canal de vazamento). With the sand firmly in place, the craneman turned the whole flask over and pulled out the pattern. The molder disassembled the two flasks and finished the molds by smoothing the surfaces and sealing them with graphite. Then he reassembled the two halves, made separate molds for the canals, and had the craneman move the partially assembled molds to the drying oven. As they were drying, the molder prepared the casting pit and coated the inside of the chill with graphite powder. Finally, the craneman moved the dried molds to the casting area, where the molder mounted them onto the ends of the chill, attached the canals, and guided the craneman as he placed the structure in the casting pit.

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The DEN: Supplying the Power to Produce and Maintain

The prime example of a technically strategic department is the Departamento de Energia (DEN), which supplied the entire mill with water, steam, electrical power, and conditioned air. The head of the department worked closely with the heads of the DCO, the DAF, the DAC, the DDT, the DCQ, and the DRF, because these departments all depended on the DEN’s services. He oversaw the DEN’s production facilities and the distribution grids – water and steam pipes, power lines, and electrical substations; and he was responsible for scheduling downtimes of these systems to allow for new installations and for maintenance. The DEN had a workforce of little more than 200 men. Much of their time, in almost all positions, was spent monitoring the equipment for possible damage or malfunctioning. The line inspectors, for example, checked all the power lines and the water, steam, and air pipes every week for abnormalities (anormalidades). The operators – whether it was in the power station, the water treatment plant, or the pump house – all kept logbooks (livros de ocorrência) to report any irregularities in the operation of the equipment under their responsibility. Their work required concentration rather than physical strength, and they had to respond quickly and decisively in the event of technical problems.

The DEN operated two facilities to generate steam: the blast furnace boiler house, which was part of the power station, and the waste heat boilers at the open-hearth shop. By the early 1950s, the main facility operated four boilers that produced 75,000 pounds of steam per hour, and it added two more under Plano B with capacities of 90,000 and
100,000 lbs/hour, respectively. The waste heat boiler house at the open-hearth shop had seven boilers with a capacity of 15,000 lbs/hour by the late 1950s. The rolling mills consumed 95,000 lbs/hour, the open-hearth furnaces 20,000 lbs/hour, together about 20% of the available steam, and the Central Termo-Elétrica (CTE) consumed the rest, primarily to generate electricity. The CTE operated two 6,250 kW generators by the early 1950s and tripled that capacity under Planos B and C by adding two 12,500 kW generators. It utilized some of the steam to run two turbo blowers that supplied air to the blast furnace and to operate auxiliary equipment such as lubrication pumps and the refrigeration system. The waste heat boilers at the open-hearth shop produced low-pressure steam for consumption in production departments.

Work in the power station required careful monitoring of boilers, turbines, and generators. Dozens of instruments provided data on the boilers and the physical properties of the steam: the panel for the four older boilers had 34 gauges, and the newer boilers had panels with 30 and 45 gauges, respectively. The boiler operator did a round every hour to check whether the gauges indicated any malfunction and to determine whether the steam was within specifications. If the readings did not meet specifications, the operator manipulated valves and levers to raise or lower water levels, raise or lower the temperature, or release pressure. The “responsible operator” (operador responsável) assumed control anytime an alarm indicated a major problem, and worked on a solution assisted by the regular operator. About three or four times per shift the operator had to switch the boilers over to a different fuel, for example from coke oven gas to blast furnace gas or from blast furnace gas to coke dust. The operation of the generators and the blowers also required constant monitoring for unusual noises, dust deposits in the valves, and overheating bearings, lubricating oil, or refrigeration fluid. Their operators adjusted the load to the demand for power and air, respectively.

It was a delicate task to start up boilers, generators, and blowers, or to shut them down. The first step for the boiler operator in starting was to open the valves for the water supply. He verified the water level, adjusted it, if necessary, before he opened the valves for the connecting pipes and the instruments. He ventilated the combustion chamber, checked the level of induced draught, drained the gas pipes, and introduced the torch into the chamber to initiate the combustion. He monitored the water supply and the fire as he
brought the boiler pressure up to a test level, drained the steam pipes, and equalized the pressure between boiler and pipes to prepare supplying steam. Only then would he bring the pressure in the boiler up to the level of regular operations.\textsuperscript{66} The operation of generators and blowers of course depended on the availability of steam. The generator operator first directed steam to the oil pump for the ratchet (\textit{catraca}), before he started the ratchet to slowly start the turbine movement. He then opened the steam valves to the turbine itself and waited until turbine speed exceeded ratchet speed to switch off the ratchet. He carefully monitored the movement of the valves and the operation of the lubrication system before he opened the turbine’s main steam valve and ordered the auxiliary operator to start the compressor. As he brought the speed up to 500 rpm, the operator checked for vibrations and noises, always prepared to stop the operation immediately. Once the turbine temperature was sufficiently high, he gradually increased the speed to 3,000 rpm and activated the refrigeration system to cool the lubricating oil. After a last check of the safety mechanisms, he would then authorize the electrical operator to connect the generator to the grid.\textsuperscript{67} Starting the turbo blower, also a steam-driven turbine, required the same basic steps and the same careful monitoring throughout the process to prevent any damage to the turbine.\textsuperscript{68} The auxiliary equipment operators were responsible for the lubrication of all moving parts and the refrigeration of the pipes.\textsuperscript{69}

The distribution of power had to be as reliable as its generation. All departments used some electrical power; the greatest consumers were the primary mills, the cold rolling mills, and the tinning department. The CSN generated between 35 and 50\% of the electricity in the CTE and purchased the rest from \textit{The Rio de Janeiro Tramway, Light, and Power Company Ltd.} (LIGHT), which operated the Fontes hydro-electrical plant in nearby Pirai. In the early 1950s, the CTE generated up to 12,500 kW, and LIGHT supplied up to 20,000 kW; by the late 1950s, the CTE had capacity of 37,500 kW and LIGHT supplied up to 35,000 kW.\textsuperscript{70} The CTE supplied the smaller consumers in the mill, such as the foundry, the maintenance shops, the water treatment plant, the pump house, and the steel works; the electricity purchased from LIGHT powered the rolling mills. The DEN was in constant contact with LIGHT’s engineers at the hydro-electrical plant and in Rio de Janeiro to coordinate the supply of electricity, report problems with frequency or
Oliver Dinius: Technology, the Division of Labor, and Workers Power…

voltage, and decide on the rationing schedule in times of power shortages. The CSN’s main substation transformed the outside power to the voltage of the internal power lines, most at 6.9 kV, some at 35.5 kV, which delivered the power to the departments through their respective substations. Every rolling mill had a control house to manage the supply of power and monitor fluctuations in voltage and currents to prevent damage to the equipment.

The main task for transmission was to monitor the supply of power and the loads at the individual substations to be able to adjust the distribution. The Chefe da Divisão de Eletricidade e Distribuição Geral had to calculate the mill’s overall power consumption and coordinate the generation, receipt, transformation, conversion, and distribution of electricity. Any temporary or permanent changes to the CSN’s electrical grid occurred under his direct supervision. A technician carried out the actual calculations of power production, consumption, and the capacities of cables and power lines, and he also paid daily visits to all the substations to supervise their operations. The substation operators and the CTE’s electrical operators were among the mill’s technically most strategic workers, because they had to implement the department head’s and the technician’s instructions. Operator of the Sub-Estação Principal (SEP) and foreman of the CTE (mestre da CTE) were the most important positions within the system. The SEP transformed the power supplied by LIGHT and fed it into the internal grid for consumption in the rolling mills, and, in emergencies, also to supplement the power supplied by the CTE. The operator of the SEP handled technical problems in the substation and responded to irregularities in the power supply, which could include disconnecting the entire mill or major parts from the outside grid. He also supervised the operators who maintained the two main power lines between the LIGHT’s Volta Redonda substation and the CSN. The CTE foreman occupied a similar position, albeit in much closer cooperation with the workers who generated the electrical power. He communicated any difficulties with the generation facilities to the head of distribution and passed on information about changed loads from the SEP to the power station. He operated switches to link the LIGHT-supplied grid with the CTE-supplied grid, connect the CTE’s alternators and generators to the grid, and disconnect the lines from the SEP to the CTE. The subordinate electrical operators (operadores eletricistas) were responsible
for monitoring the alternators and the generators, respectively, to ensure that they supplied the right voltage and strength of current. The operators of the substations supplied by CTE monitored several panels, one for each type of line (6.6 kV, 2.3 kV, and 440V), regularly reported their readings, and did troubleshooting when a feeder circuit failed. The specific protocols for resolving problems with the power supply varied depending on the equipment and the access to the SEP as alternative power source.

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Transport and Maintenance: Moving Products, Keeping Machines Running

Transport and maintenance departments worked with all production departments and most support units. Disruptions in these services could not disrupt production as quickly and profoundly as a power outage, but these departments were still highly strategic in the technical context of the integrated steel mill.

Production consumed large quantities of bulky, extremely heavy, and often hot materials that needed to be moved between and within departments. Much of the transport between the metallurgical departments was done by rail: ladle trains moved the liquid pig iron from the blast furnace to the steel work, and flatcar trains moved steel ingots from the steel works to the rolling mills. A train moved the slag from the blast furnace to the slag yards, and the rolling mills loaded their products on railcars for delivery to the customers. There were tracks into all the large mill buildings to move equipment, and, for the mechanical shops, to bring locomotives and cars in for repairs. By the early 1960s, the Departamento de Transporte Ferroviário (DTF) had nine steam locomotives, nine diesel locomotives, six rail-mounted steam cranes, two rail-mounted diesel cranes, 31 flat cars, 58 gondola cars, 51 hopper cars, 30 tilting side dump cars, and nine tank cars. The most important workers in the department were the engineers and the firemen who operated the locomotives and steam-driven rail cranes. The Departamento de Transporte Interno (DTR) supplemented internal rail transport with a fleet of 35 dump trucks and 64 freight trucks.

Moving material and machinery within departments was done mostly by overhead traveling crane (pontes rolantes). There was no separate department to organize the work of the cranemen, but they were very independent within their respective department: they
took orders from a foreman responsible only for the overhead traveling cranes (encarregado de pontes rolantes). The steel works employed 92 men to operate twenty overhead traveling cranes by the early 1960s: three in the raw material yard, one at the hot metal mixer, five on the charging floor, three on the casting floor, two for the ingot stripper, two on the ingot floor, three in the slag yards, and one in the calcination area.\textsuperscript{79} Cranes were equally important for the rolling mills and the foundry: the DDT employed 56 men to operate thirteen cranes, the DCQ thirty to operate six cranes, and the DFU 36 to operate eight cranes.\textsuperscript{80} The raw material yards, the roll shops, and mechanical maintenance also relied on overhead traveling cranes to move material and heavy equipment.

The cranes ran on tracks, commonly between thirty and fifty feet above the shop floor. The operator worked in a cabin attached to the crane and used various levers to control its speed and travel. With another set of levers, the operator manipulated the crane’ main hoist, which had a lifting capacity anywhere between 20t and 200t. Most cranes had auxiliary hoists, for example to tilt ladles, which the operator controlled simultaneously with the main hoist.\textsuperscript{81} Safety regulations often explicitly prohibited traveling with the crane and lifting the load at the same time, but it was a matter of pride for the operators to display that level of coordination and experience. Careless operation of these cranes could have devastating consequences.\textsuperscript{82} The operators carried great responsibility, and had great strategic power: there was little work departments could accomplish without the efficient cooperation of the cranemen, simply because there was no alternative means to move these materials. Many production processes required for shop floor crews to work with the craneman constantly.\textsuperscript{83}

The CSN had specialized departments for electrical and mechanical maintenance. The Departamento de Manutenção Életrica (DME) operated an electrical shop that executed large repairs, and it had subgroups that maintained the electrical equipment of particular departments. The DME’s four subgroups served the CTE and the metallurgical units, the slabbing and blooming department (DDT), the hot rolling mill (DCH-1), and the cold rolling department (DCH-2). Auxiliary maintenance, a fifth group, was not assigned to a particular department, and was employed flexibly. The overwhelming majority of men who worked for the DME were electricians (332 out of 430). The structure of the
Departamento de Manutenção Mecânica (DMM) was similar, although it employed almost three times as many men. Its maintenance subgroups served the coke plant (DCO), blast furnace (DAF), steel works (DAC), foundry (DFU), slabbing and blooming mill (DDT), hot rolling mill (DCH-1), cold-rolling mill (DCH-2), and the Central Termo-Elétrica (CTE). In addition, the DMM maintained separate units for lubrication (lubrificação) and for the maintenance of the rolling stock (locomotives and railcars). The DMM’s shop had subdivisions to repair machinery, boilers, railway cars, and locomotives. The mechanical shops also manufactured many of the spare parts needed to repair the equipment. DMM employed a broad range of skilled trades, including about 600 maintenance mechanics, about 100 toolmakers, and more than 50 boilermakers, and painters, respectively.

The Departamento de Refratário (DRE) was initially part of the DMM, but became a separate department by the early 1960s. It employed large numbers of bricklayers with specialized knowledge of refractory materials used to line the inside of furnaces and ladles in the metallurgical departments. The range of work for refractory bricklayers went from minor repairs on smaller furnaces to a complete refurbishing of the blast furnace, which only occurred every few years. The DRE had subgroups, similar to the DME and the DMM, which served particular departments: the blast furnace (DAF), the steel works (DAC), the foundry (DFU), the slabbing and blooming mill (DDT), the hot-rolling mill (DCH-1), and the cold-rolling-mill (DCH-2). In the blast furnace and steel works, there was continuous demand for refractory work to close tap holes and to build casting canals; in the foundry, the central task was refurbishing the linings of the various smaller furnaces; in the rolling mills, it was mostly smaller repairs on the various furnaces used to reheat or anneal ingots, plate, and coil before further processing. Refractory materials were also used for the thermal insulation of pipes that carried water, steam, oil, or tar. The bricklayers’ work was often physically demanding, especially when they had to demolish the old lining before refurbishing the furnace. Still, they needed enough knowledge of the materials for the occupational descriptions to classify their work as “technical.”

The Departamento dos Cilíndros (DDC), responsible for the maintenance of the rolls in close cooperation with the foundry. The DDC’s shop had two subdivisions, one for the
rail and structural mill and the other for the flat-rolling mills. Every month, the DDC prepared about 45 rolls for their first use, rectified the surfaces of about twenty rolls for the rail and structural mill, and refurbished close to 2,000 used rolls for flat-rolling.88 Rolls were sometimes cast wider than specifications to insure the slow cooling of its thinner sections; in those cases, the DDC’s lathe operators (torneiros) had to remove excess metal before the rolls could be used.89

The DME, DMM, and DRE all had specialized groups supporting individual departments. Their task was two-fold: on the one hand, they tried to preempt any major equipment damage through regular, scheduled maintenance routines; on the other hand, they responded to emergencies in order to restore equipment to working order as quickly as possible. It is difficult to single out equipment that took particular attention by the maintenance crews, precisely because mill operations were so deeply integrated. The equipment that required both electrical and mechanical maintenance was probably of greatest concern: the boilers in the power station, the overhead traveling cranes, and the rolling mills.

The DEN’s equipment, for example, underwent regular maintenance. The department’s electricians fixed minor problems themselves, but relied on the Departamento de Manutenção Elétrica (DME) for larger repairs that required special equipment or specialized training. The DME had a subunit that worked specifically with the DEN, the DME/DEN. It employed between ten and fifteen electricians to carry out scheduled maintenance operations on the electrical equipment in the CTE, the waste heat boiler house, the pump station, the water treatment plant, and all the electrical substations. Its head foreman needed profound knowledge of all the equipment, including the English technical terms, to direct the work of the maintenance crews.90 The maintenance electricians inspected, disassembled, tested, repaired, reassembled, and lubricated equipment as varied as engines, generators, contacts, contactors, coils, relays, voltage regulators, safety instruments, and magnetic pulleys.91 Most of the time, it was sufficient to install a spare part or carry out on-site repairs, but occasionally they replaced entire engines or panels.92 Auxiliary electrical maintenance (DME/A) assisted the DME/DEN with the removal and repair of major pieces of equipment, such as generators, transformers, or oil switches (chaves a óleo), and it also maintained the transmission
The foreman responsible for the maintenance of transmission lines had to be intimately familiar with the CSN’s grid to be able to “identify with certainty the ones that needed repair.”

1 For a concise overview of the technology and the economics of the Brazilian steel industry, see Werner Baer, The Development of the Brazilian Steel Industry (Nashville: Vanderbilt University Press, 1969), 8-30.

2 A nice illustration for this interdependence is the “Flow Diagram – Raw Materials to Finished Product” in Freyn Engineering Department, Koppers Company, Companhia Siderúrgica Nacional, Volta Redonda, Report for Plan C Expansion of Plant Capacity to 1,000,000 metric tons of ingots per year (Chicago, July 11, 1952), appendix.

3 He provides examples of Basisstreiks (=wildcat strikes) at the departamental level in the 1910s, 1920s, and 1930s that took advantage of this “Störmacht.” Thomas Welkopp, Arbeit und Macht im Hüttenwerk. Arbeits- und industrielle Beziehungen in der deutschen und amerikanischen Eisen- und Stahlindustrie von den 1860er bis zu den 1930er Jahren (Bonn: J.H.W. Dietz, 1994), 573-583.


5 “Influência diretamente no processo podendo constituir gargalo na operação.” CSN. Folha de Descrição de Trabalho: Operador da 1.ª Balança e Carro Lingote (DDT-D), 16/05/1964.

6 “A retirada da carepa dos poços através das bombas influencia no processo uma vez que o acúmulo de carepa acarreta paradas.” CSN. Folha de Descrição de Trabalho: Operador do Carro de Pontas da Tesoura à Quente (DDT-D), 18/03/1964.


8 Freyn Engineering, Companhia Siderúrgica Nacional, 210-225.


12 In 1951, the overall production reached 301,000 tons of steel. Freyn Engineering, Companhia Siderúrgica Nacional, 50. For an exemplary listing of the products and the CSN’s production record for the years 1949/50, see CSN. Relatório da Diretoria - 1950, 6.

Three sources were essential for the analysis of the division of labor by department. The standard reference for U.S. and Brazilian metallurgical engineers at the time was US Steel Company, The Making, Shaping, and Treating of Steel, Sixth Edition (Pittsburgh: US Steel, 1951). The text makes occasional reference to the specific tasks of workers, but commonly the description is limited to the machinery and the physics and chemistry of the production process. The most useful source to make sense of the job descriptions was a volume prepared by a joint commission of US Steel and the United Steelworkers of America. Unfortunately, it omits foremen and higher positions. United Steelworkers of America (CIO) & US Steel Corporation, Job Descriptions and Classification Manual for Hourly Rated Production, Maintenance and Non-Confidential Clerical Jobs, January 1, 1953. Starting in the early 1950s, the CSN’s Engenharia Industrial created its own job descriptions, the Folhas de Descrição de Trabalho. The CSN hired the U.S. consulting firm Bruce A. Payne & Associates to assist with the introduction of these scientific management practices in Volta Redonda. Eng. Ervin Michelstaedter, former head of the CSN’s Engenharia Industrial, interview by author, Volta Redonda, July 22, 1998.

Technical dictionaries were essential to match the terms from the English literature on steel-making and the US Steel job descriptions with the CSN’s Folhas de Descrição de Trabalho. The earliest dictionary with comprehensive coverage of technical terms in Portuguese was Francisco J. Buecken, Vocabulário Técnico: Português-Inglês – Francês – Alemão, 2.ª Edição, Revista e aumentada de 5000 novos termos (São Paulo: Melhoramentos, 1952). The Associação Brasileira das Normas Técnicas supported the creation of the dictionary, with 37,000 entries in its first edition (1946) and a substantially improved coverage in the cited second edition (55,000 terms). At about the same time, the first British dictionary with a decent coverage of industrial terms in Portuguese appeared, Alfred Elwes, A Dictionary of the Portuguese Language. In two parts: 1. Portuguese-English. 2. English-Portuguese, including a large number of technical terms used in mining, engineering, etc. (London: Technical Press, 1948).

Unfortunately, to this day many of the multilingual technical dictionaries do not cover Portuguese, or only offer cross-referenced indices (índice remissivo), as is the case with Michel Feutry/Robert M. de Mertzenfeld/Agnès Dollinger, Dicionário Técnico Industrial. Tratando de áreas de: Mecânica, Metalurgia, Electricidade, Química, Construção Civil e Ciências Exatas. Inglês – Francês – Alemão – Espanhol – Português (Belo Horizonte: Garnier, 2001). The first, and to my knowledge only, dictionary specifically on iron and steel with Portuguese coverage is the Dicionário Siderúrgico Trilingüe: Inglês – Espanhol – Português (Santiago de Chile: Instituto Latinoamericano del Fierro y del Acero – ILAFA, 1994). An older multilingual dictionary, with excellent organization and useful illustrations, but without Portuguese coverage, is maybe the best to visualize the equipment used in steel factories; Dictionnaires Techniques Illustrés (En six langues: Français, Allemand, Anglais, Russe, Italien, Espagnol.). Tome XI: Siderurgie (Paris: Dunod, Munich et Berlin: R. Oldenbourg, 1911).

For a flow diagram of the production process and the utilized equipment before and after the implementation of Plano B and the projected line-up after the implementation of Plano C, see “Rolling Mills Flow Diagram”, in Freyn Engineering, Companhia Siderúrgica Nacional, appendix to section 1.

This discussion of the administrative structure reflects the situation in 1951, after a series of changes to the organizational tree in the late 1940s. In 1949, the DI still had “sectors” as the largest subunits: there were eight sectors subdivided into 31 departments. Some of the departments were renamed into divisions, but their internal organization was largely unaffected by these changes. BSVR 132 (12/07/1949), 1281-1285.

“Organograma da Direção Industrial,” BSVR 147 (05/08/1951), appendix, I-XVIII. The Volta Redonda sector also included four small departments subordinate to the president and the financial director, respectively. Together, they had less than 500 employees, all white-collar, who reported directly to the main office in Rio de Janeiro. “Efetivo de Pessoal,” BSVR 004 (05/01/1951), 31-40.

For the distribution by skill level in the iron & steel units, see “Quadro de Pessoal - DCO - Aprovação,” BSVR 015 (23/01/1950), 113-114 and BSVR 155 (20/08/1951), IV/V; “Departamento de Alto Forno,” BSVR 160 (27/08/1951), I-III; “Departamento de Aciaria - Lotação Numérica Aprovada,” BSVR 160 (27/08/1951), appendix, II-III, “Departamento da Fundição,” BSVR 160 (27/08/1951), II-IV. For the rolling and finishing mills, see “Departamento Desbastador de Trilhos - Lotação Numérica Aprovada,” BSVR 160...
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19 These totals omit all departments that are not directly involved with the production process, specifically administration (e.g. personnel, finance, purchasing) and general services (industrial security, social assistance). To avoid distortions in the skill levels, the table moreover excludes high administrative positions (chefes, técnicos). In January 1951, the CSN’s staffing plans listed a nominal workforce of 9,802 including the occupations omitted in this table. Because of unfilled vacancies, however, the actual number of employees on payroll was only about 9,000. See BSVR 004 (05/01/1951), 31-40.

20 The head of the hot-rolling department (DCQ), for example, had orders to remain in regular contact with no less than nine other departments: 1) DCB for maintenance of instruments for the reheating furnace; 2) DDT to provide feedback on quality of slabs and to coordinate overhead; traveling crane use; 3) DCF to receive feedback about the quality of the hot-rolled coils; 4) DMM and DME to schedule stoppages for equipment repairs; 5) DRE to schedule stoppages of the reheating furnace and the pickling line; 6) DPP to discuss issues related to the production plan for DCQ; 7) DEX to discuss the delivery of products for export; 8) DDC to discuss issues related to the cylinders used by the DCQ. In addition, he had to be in touch with more than a dozen of the other departments “whenever need arose.” CSN, Folha de Descrição de Trabalho: Chefe do DCQ, 25/07/1962.

21 CSN, Folha de Descrição de Trabalho: Operador de Carro Balança. (DAF), 03/12/1963; Standard Title – Larryman (Code BA 01970), USW, Job Descriptions, 85.

22 CSN, Folha de Descrição de Trabalho: Forneiro de Alto Forno. (DAF), 19/11/1963; CSN, Folha de Descrição de Trabalho: Encarregado de Tumos de Alto Forno. (DAF), 18/10/1962; and Standard Title – Keeper (Code BA 01940), USW, Job Descriptions, 139.

23 CSN, Folha de Descrição de Trabalho: Escoreiro. (DAF), 18/11/1963; and Standard Title – Cinder Snapper (Code BA 05430), USW, Job Descriptions, 105.

24 For job descriptions in the blast furnace department, see CSN, Folhas de Descrição de Trabalho. (DAF); USW, Job Descriptions, 80-139.

25 CSN, Folha de Descrição de Trabalho: Operador do Misturador. (DAC), 26/05/1965; Standard Title – Mixer Operator (Code BA 03540), USW, Job Descriptions, 181.

26 CSN, Folha de Descrição de Trabalho: Mestre de Forno S.M.. (DAC), 02/10/1962.

27 CSN, Folha de Descrição de Trabalho: Mestre de Fusão. (DAC), 05/11/1962.

28 CSN, Folha de Descrição de Trabalho: 1º Paneleiro Lingotador. (DAC), 24/01/1964; Standard Title – First Steel Pourer (Code BA 04550), USW, Job Descriptions, 175.

29 For job descriptions in the steel works department, see CSN, Folhas de Descrição de Trabalho. (DAC); USW, Job Descriptions, 168-219.
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31 CSN, Folha de Descrição de Trabalho: Operador da 1ª Balança e Carro Lingote, (DDT), 16/05/1964; Standard Title – Ingot Buggy Operator (Code BA 03360), USW, Job Descriptions, 221.


33 For job descriptions in the blooming and slabbing mill department, see CSN, Folhas de Descrição de Trabalho, (DDT/D); USW, Job Descriptions, 220-229 and 334-358.

34 As part of the expansions in the 1950s, the CSN added a 2-high scale breaker and a 28” and 53” by 72” 4-high roughing stand to the plate mill, turning the old rougher into the second stand of a three stand set-up. The company also added two stands, technically identical to the existing four, at the hot-strip mill. See “Rolling Mills Flow Diagram”, in Freyn Engineering, Companhia Siderúrgica Nacional, appendix to section 1.

35 CSN, Folha de Descrição de Trabalho: Mestre de Fornos e Reaquecimento de Placas, (DCQ), 12/11/1962; and Standard Title – Slab Heater (Code BA 01800), USW, Job Descriptions, 461.

36 On the operation of 4-high reversing plate mills, see US Steel, The Making, 755-762. See also CSN, Folha de Descrição de Trabalho: Mestre dos Laminadores a Quente, (DCQ), 17/12/1962.


39 CSN, Folha de Descrição de Trabalho: Encarregado do Acabamento de Chapas Finas a Quente (DCQ), 16/01/1963.


41 CSN, Folha de Descrição de Trabalho: Mestre de Vazamento (DFU), 20/10/1962.

42 Freyn Engineering, Companhia Siderúrgica Nacional, 184-185.


44 CSN, Folha de Descrição de Trabalho: Chefe de Moldação de Cilindros, Lingotetiras, e Assentos (DFU), 22/10/1962.

45 CSN, Folha de Informações para Avaliação de Trabalho: Delineador da Preparação (DFU), 03/05/1956; CSN, Folha de Informações para Avaliação de Trabalho: Delineador da Programação (DFU), 25/04/1956; CSN, Folha de Informações para Avaliação de Trabalho: Anotador da Modelação (DFU), 11/03/1955; CSN, Folha de Descrição de Trabalho: Controlador de Produção (DFU), 30/03/1964.


47 CSN, Folha de Descrição de Trabalho: Modelador (DFU), 21/06/1963; ; Standard Title – Pattern Maker (Code BA 02310), USW, Job Descriptions, 822.
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49 CSN, Folha de Descrição de Trabalho: Chefe de Modelação (DFU), 22/10/19/62; CSN, Folha de Descrição de Trabalho: Mestre Moldador (DFU), 05/06/1963. The “U” presumably stood for “Urgente.” The Portuguese term “delineamento” translates as “sketch,” but the occupational descriptions suggest that it was responsible for setting the foundry’s production schedule. CSN, Folha de Informações para Avaliação de Trabalho: Delineador da Preparação (DFU), 03/05/1956; CSN, Folha de Informações para Avaliação de Trabalho: Delineador da Programação (DFU), 25/04/1956.

50 CSN, Folha de Descrição de Trabalho: Aferidor e Encarregado de Modêlos (DFU), 03/06/1963; Standard Title – Pattern Stocker (Code BA 05590), USW, Job Descriptions, 824; Standard Title – Pattern Checker (Code BA 00660), USW, Job Descriptions, 823.


52 Standard Title – Core Maker (Code BA 02210), USW, Job Descriptions, 800.

53 CSN, Folha de Descrição de Trabalho: Modelador (DFU), 21/06/1963.

54 CSN, Folha de Descrição de Trabalho: Machoio para Peças (DFU), 19/06/1963; CSN, Folha de Descrição de Trabalho: Encarregado da Macharia (DFU), 19/06/1963; Standard Title – Core Maker (Code BA 02210), USW, Job Descriptions, 800.

55 The CSN did not produce its own rolls for the slabbing and blooming mill or the cold rolling mills, at least not in these years. Those were still imported.


57 For an illustration, see US Steel, The Making, 566.


59 The DEN had originally been part of the Departamento de Combustão (DCB). The DCB remained in charge of combustion (oil, gas) in the production departments when the CSN created the DEN in the 1950s after the expansion under Plano B.

60 CSN, Folha de Descrição de Trabalho: Inspetor de Linhas (DEN/V), 19/03/1965.

61 The most important fuels to generate the steam were coke oven gas and blast furnace gas. Most of the coke oven gas went to the open hearth furnaces, the soaking pits, and the furnaces for slabs, reheating, and annealing; most of the blast furnace gas went to the coke plant, the blast furnace itself, and the soaking pits. However, during regular operation, these units had a gas surplus with almost 120 million calories of energetic content that the power station could use to produce steam. Freyn Engineering, Companhia Siderúrgica Nacional, 166-169 and appendix “Fuel Distribution Chart.”

62 It used 220,000 lbs/hour for power generation and 126,000 lbs/hour to operate the turbo blowers for the blast furnaces, and 60,000 lbs/hour for auxiliaries. The consumption figures are all for the later 1950s, after the implementation of Plano C. Unfortunately, the Freyn report does not provide steam consumption figures for the early 1950s. Freyn Engineering, Companhia Siderúrgica Nacional, 173-174.

63 CSN, Folha de Descrição de Trabalho: Operador de Caldeiras do DAC (DEN/V), 18/11/1964; CSN, Folha de Descrição de Trabalho: Operador Responsável - Caldeiras do DAC (DEN/V), 20/01/1964.
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64 CSN, Folha de Descrição de Trabalho: Operador de Caldeiras da CTE (DEN/V), 09/01/1964; CSN, Folha de Descrição de Trabalho: Operador Responsável de Caldeiras da CTE (DEN/V), 31/01/1964.

65 CSN, Folha de Descrição de Trabalho: Operador Responsável Turbo Soprador (DEN/V), 21/01/1964; CSN, Folha de Descrição de Trabalho: Operador Turbo Soprador (DEN/V), 22/01/1964; CSN, Folha de Descrição de Trabalho: Operador de Turbo Gerador (DEN/V), 05/05/1961; CSN, Folha de Descrição de Trabalho: Operador de Turbo Gerador (DEN/V), 19/11/1963.

66 CSN, Folha de Descrição de Trabalho: Operador de Caldeiras da CTE (DEN/V), 09/01/1964; CSN, Folha de Descrição de Trabalho: Operador Responsável Caldeiras da CTE (DEN/V), 31/01/1964.

67 CSN, Folha de Descrição de Trabalho: Operador do Turbo Gerador (DEN/V), 05/05/1961.

68 CSN, Folha de Descrição de Trabalho: Operador Responsável Turbo Soprador (DEN/V), 24/01/1964.

69 CSN, Folha de Descrição de Trabalho: Operador de Máquinas Auxiliares de Caldeiras (DEN/V), 03/12/1963; CSN, Folha de Descrição de Trabalho: Operador de Compressores e Máquinas Auxiliares Turbinas (DEN/V), 18/11/1963.

70 Freyn Engineering, Companhia Siderúrgica Nacional, 175-178 and appendix “Electric Single Line Diagram.”


73 CSN, Folha de Descrição de Trabalho: Técnico de Distribuição de Energia Elétrica (DEN/E), 22/07/1966.


75 The operation of these disconnecting switches (disjuntores) at the SEP was done by a remote system, the so-called “Visicode.” CSN, Folha de Descrição de Trabalho: Mestre da CTE (DEN/E), 17/08/1966.

76 CSN, Folha de Descrição de Trabalho: Operador Eletricista “B” - CTE (DEN/E), 22/03/1961; CSN, Folha de Descrição de Trabalho: Operador Eletricista “A” - CTE (DEN/E), 21/03/1961.


78 Arthur McKee, Report for Companhia Siderúrgica Nacional, 4/19 and 4/20. These numbers only cover rail transport inside the mill. The company also operated trains to transport coal from the coastal ports and iron ore from Minas Gerais to Volta Redonda. It also maintained a small fleet of freight ships to transport coal between Santa Catarina and Angra dos Reis and even from the United States. Edmundo de Macedo Soares e Silva, “Volta Redonda - Gênese da idéia, seu desenvolvimento, projeto, educação e custo,” Revista do Serviço Público (nov.1945), 24; and Edward J. Rogers, “Brazilian Success Story: The Volta Redonda Iron and Steel Plant,” Journal of Inter-American Studies X:4 (Oct.1968), 647.

79 CSN, Folha de Descrição de Trabalho: Encarregado de Ponte Rolante (DAC), 06/12/1962.
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80 CSN, Folha de Descrição de Trabalho: Encarregado de Ponte Rolante (DDT), 09/11/1964; CSN, Folha de Descrição de Trabalho: Encarregado dos Serviços de Pátio e Forno (DCQ), 30/10/1962; CSN, Folha de Descrição de Trabalho: Encarregado de Ponte Rolante (DFU), 03/12/1962. The occupational descriptions for the cold-rolling mills are not complete enough to provide comparable figures for the early 1960s. For the early 1950s, the DCF staffing plan listed 33 crane operators, at a time when the DDT employed 33 and the DCQ 22. “Departamento de Chapas - Lotação Numérica Aprovada,” BSVR 162 (05/09/1951), I-IV.

81 Standard Title – Ladle Craneman (Code AD 00940), USW, Job Descriptions, 175.

82 One particularly tragic work accident illustrates the dangers. A laborer on the shop floor had improperly hooked a ladle to the crane; as the crane operator lifted the ladle and began to move the ladle laterally, the hook came loose, the ladle tilted, and the molten steel poured onto the shop floor, instantly killing half-a-dozen workers. The occupational description for operators of the pontes rolantes that moved ladles with molten steel emphasized that the men had to “follow the safety norms rigorously;” this was the only underlined word in all the job descriptions I have seen. CSN, Folha de Descrição de Trabalho: Operador de Ponte PR’s 26, 27 & 220 (DFU), 19/03/1959.

83 For an impressive example of this constant dependence on the crane operators, see the discussion of roll casting in the foundry (above).

84 By the early 1960s, these groups had been joined into a new department – the Departamento da Manutenção das Unidades (DMU).

85 See also: “Departamento de Manutenção Elétrica & Departamento de Manutenção Mecânica - Lotação Numérica Aprovada,” BSVR 162 (05/09/1951), IV-VIII.


87 CSN, Folha de Descrição de Trabalho: Pedreiro de Refratário no DFU-DOF (DRE), n.d.; CSN, Folha de Descrição de Trabalho: Pedreiro Responsável Laminação (DRE), n.d.; CSN, Folha de Descrição de Trabalho: Pedreiro da Manutenção – Plantão DAC (DRE), n.d..

88 CSN, Folha de Descrição de Trabalho: Operador de Ponte 230 (DDC), 15/03/1965.


90 CSN, Folha de Descrição de Trabalho: Mestre Geral (DME/DEN), 19/10/1962.

91 CSN, Folha de Descrição de Trabalho: Eletricista de Turno (DME/DEN), 10/05/1965.

92 CSN, Folha de Descrição de Trabalho: Eletricista Auxiliar (DME/DEN), 10/05/1965.

93 CSN, Folha de Descrição de Trabalho: Mestre Geral da Manutenção Elétrica Auxiliar (DME/A), 23/10/1962.

94 CSN, Folha de Descrição de Trabalho: Mestre da Manutenção das Rêdes Aéreas e Subterrânea (DME-A), 05/04/1965.