

# The Mechanical Engineering Industry in Catalonia

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## ABSTRACT

After an introduction in which he gives a broad outline of industrialization in Catalonia and the Valencian Country, the author focuses on the manufacture of heavy machinery in Catalonia. This enables him to present the major factories which brought prestige to Catalonia, including Nuevo Vulcano, Alexander y Hermanos, and La Maquinista Terrestre y Marítima. The account he gives of the locomotives made by La Maquinista (Spain's largest locomotive manufacturer) provides an opportunity to define the modest scale of industrialization in Catalonia in comparison with other parts of Europe. The author considers that the obstacles that hindered the country's modernization were largely associated with excessive variety of output, brought about by deficient and relatively scarce demand, all of which accounts for the continual calls for protectionism made by Catalan industrialists.

Even so, the author concludes that the only parts of Spain where it is possible to refer to industrialization in the 19th and early 20th centuries are Catalonia and the Basque Country.

**KEY WORDS:** Industrialization, locomotive, bridge, protectionism, steam engine, turbine

## NOTES ON THE INDUSTRIALIZATION OF CATALONIA

The industrialization of Catalonia was characterized by its early start and its steady development. The process was related by Pierre Vilar in an excellent work, in which he examined why and how it occurred.<sup>1</sup> Since then much study and research has been carried out and today it is possible to offer a fairly complete overview.

The first point to stress is that the process got underway in the 18th century, especially the second half of the century, when socio-economic conditions in Catalonia were optimal.<sup>2</sup> However this first wave of development, which was concentrated in the cotton textile sector, was curbed first by the wars against the British and the Napoleonic Wars, and later by the establishment of absolute rule under Ferdinand VII. At the end of the 1820s, the trend towards industrialization resumed. Some consider that the starting point was 1832, the year in which Catalonia's first steam engine was installed in a textile mill belonging to the Barcelona firm Bonaplata, Rull, Vilaregut y Compañía.<sup>3</sup>

During the 1830s and 1840s the cotton sector grew fast. Spinning was mechanized between 1835 and 1860; weaving followed suit, but more slowly, as happened in other countries. These developments triggered the construction of large factories on urban land. Since the energy to drive them was generated by coal, they were known as *Vapors* ('steams'). The most characteristic were La España Industrial, founded by the Montadas brothers (1847) and nicknamed 'El Vapor Nou' ('The New Steam'), and 'El Vapor Vell' ('The Old Steam'), founded by Güell i Ferrer in Sants in 1840.<sup>4</sup>

In 1848 Spain's first railway line was inaugurated. It ran from Barcelona to Mataró and was the first link in the state-wide network.

Both the aforementioned advances — plus the construction of fleets of merchant and war ships — gave a boost to the steel industry and encouraged the creation of firms for making heavy machinery in general and steam engines in particular.<sup>5</sup>

Let us now consider the Valencian Country. In the 1960s it used to be thought that industrialization had passed the region by but this view has gradually been modified by studies and research and scholars have now concluded that the Valencian Country experienced considerable industrial development. Thus Jordi Nadal claims,<sup>6</sup> on the basis of regional levels of industrialization, that in 1900 the Valencian Country was the second most industrialized region in Spain after Catalonia, having

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overtaken Andalusia, which ranked second during the 19th century (he excludes the Basque Country and Navarre, which had a different tax system):

1856			
Region	% of output	% of population	Level of industrialization
Catalonia	25.60	11.22	2.28
Andalusia	24.05	19.89	1.21
New Castile	9.81	10.02	0.98
1900			
Region	% of output	% of population	Level of industrialization
Catalonia	38.58	11.11	3.47
Valencian Country	8.31	8.25	1.01
Andalusia	19.08	20.13	0.95

(*Estadística administrativa de la contribución industrial y de comercio* for the years 1856 (1857) and 1900 (1901); 1857 and 1900 population censuses. The percentages of output and regional population have been calculated on the totals for Spain, and the level of industrialization is obtained by dividing the two aforementioned percentages. Quoted in NADAL, J., CARRERAS, A., *Pautas regionales de la industrialización española, siglos XIX y XX*, Barcelona, Ariel, 1990, p. 298).

Moreover, the fact that both steam engines and water turbines were installed in the Valencian Country is proof of the existence of industrialization. Between 1846 and 1883, 157 steam engines made by Alexander Hermanos were fitted in the Valencian Country; in and around the city of Valencia there were 78 in operation in 1879 and 39 new permits were issued in the following three years. There is evidence, too, that 100 turbines (producing a total of 7,600 HP) out of over a thousand turbines built by the firm Planas, Flaquer y Compañía in 1910 were for delivery to the Valencian Country.<sup>7</sup>

The Balearic Islands, on the other hand, lie outside of the scope of this article on account of their island geography and their intrinsic characteristics.

A few words about the emergence of a Catalan steel industry are in order before we focus our attention on mechanical engineering.

One of the handicaps the industrialization of Catalonia came up against was the country's lack of coal and iron ore. Despite this, Catalan entrepreneurs, realizing that it was absolutely essential to produce heavy machinery if industrial development was to go ahead, embarked on the adventure of building their own steel furnaces.<sup>8</sup>

Catalonia had six steel works. The first was built in Camprodon in 1844 by the firm El Veterano Cabeza de Hierro. It originally ran on charcoal but was to be converted to coke when coal from Sant Joan de les Abadesses became available. And it was indeed adapted to burn coal fourteen years later, though its operation was fraught with

difficulties and its productivity was low. There is evidence that cast iron was being produced at Herrería Catalana in La Bordeta (Sants) between 1851 and 1856 and that the Alexander brothers, to whom we will refer later on, set up a third blast furnace at El Clot de la Mel, in the borough of Sant Martí de Provençals. In the 1850s three more steel-works commenced operation, two in Anglès and one in La Garriga, bringing the total to six. However, in the wake of Salaverri's customs law of 1862, the price of imported iron fell and this put an end to what we have referred to as the Catalan blast furnace 'adventure'. By 1866 all the furnaces had ceased production and the metallurgical industry had settled, once and for all, in Northern Spain.<sup>9</sup>

The only major steel manufacturing complex in the Catalan Countries was to be located in Sagunt and this was not founded until later on.

When the Basque industrialist Ramón de la Sota and his partner Eduardo Aznar were looking for iron ore deposits for the Basque steel industry, they rented the mines of Ojos Negros (Teruel) and had to build 205 km of railway tracks to carry the ore to the port of Sagunt. They began working the mine in 1906. An ore improvement plant, comprising a plant for making pellets and a furnace, was located on the quayside at the new harbour, a few kilometres from the old harbour of El Grau. This plant became the nucleus of the future steel works.

In 1917 the Compañía Siderúrgica del Mediterráneo was founded and in 1922 its first blast furnace went into operation. Seven years later output peaked at 139,655 tonnes. By then the plant employed 4,000 workers, twice as many as in 1923. After 1929, owing first to the economic crisis and then to the Civil War, production fell off and ultimately was halted. In the aftermath of the Civil War the complex was taken over by Altos Hornos de Vizcaya, which started it up again. Because of the overall situation, recovery was slow and output did not catch up with 1929 levels until 1954.

In the second half of the 1960s Spain experienced a new wave of industrialization and the plant was turned into a complete steel-making complex (Altos Hornos del Mediterráneo). Finally, the restructuring of the sector towards the end of the 1970s brought about its closure.

## THE MANUFACTURE OF MACHINERY IN CATALONIA

We will now examine a few of the factories and workshops in Catalonia and the Valencian Country which made heavy machinery, starting with Catalonia.

### Nuevo Vulcano

The first firm we will discuss was called Nuevo Vulcano. The precise year of its foundation is not known. What we do know is that it got off the ground thanks to a shipping company — the Compañía Catalana de Vapores — somewhere between 1833 and 1835.<sup>11</sup>

The Compañía Catalana de Vapores had been set up in 1833 and the engines for the steamship “Delfín”, which underwent its first trials in 1836, were made by its subsidiary, a boilermaker’s shop in La Barceloneta known as Nuevo Vulcano. The “Delfín” and the “Balear” were its first ships. They were followed, slightly later on, by the “Mercurio” which, like the “Balear”, was built in Liverpool.

As the shipping company grew, the idea of setting up a new firm took shape. Its name was Navegación e Industria and its aim was “to facilitate navigation and the transport of merchandise in steamships, and the exploitation and working of coal mines which it has already bought and those it may consider it appropriate to acquire at some future time”.<sup>12</sup> It also reserved the right to undertake other commercial activities.<sup>13</sup> Navegación e Industria was incorporated on 23 March 1841. Naturally, the Nuevo Vulcano works, which had been fitted with the latest equipment for making marine engines and boilers, also became part of it. To put Nuevo Vulcano’s equipment to the best possible use, the idea of repairing engines from other ships, both foreign and Spanish, was also considered. By the beginning of the 1850s the plant had an English technical director, four foremen, twelve skilled workers and twelve apprentices. And it was going ‘full steam ahead’.

In the mid-1850s, the importance of shipping within the company declined while the importance of the factory grew. A large number of steam engines and boilers were built there (fifty boilers have been counted in the five years from 1856 to 1861) and the Spanish Admiralty became one of its customers.

In 1866 the company gained new vitality when it was granted the government contract to run the mail service to the Canary Islands. Nuevo Vulcano also benefited from the favourable situation that was starting to emerge and stepped up construction of stationary steam engines, for use in small industries and agriculture, and water pumps. The foreman was now Joseph White, who had acquired experience of the trade by opening a small factory of his own in Barcelona in 1849. White designed the steam engine for the “Remolcador”, one of the first ships entirely built in Catalonia, which came out of the Barcelona shipyard run by Pere Sisteré in 1849.<sup>14</sup>

Needless to say — for the reader will already have inferred this — the fortunes and misfortunes of the mechanical engineering plant were closely linked to the ups and downs of the shipping company, something which did not occur in other firms — Alexander Hermanos and La Maquinista Terrestre y Marítima — as we will see later on. In 1885, when the political and economic context was leaning clearly towards protectionism, Nuevo Vulcano was commissioned to make the engines and boilers for several gunboats and the warship “Elcano”.

In 1916 the Compañía Trasmediterránea was set up in Barcelona as a result of a merger involving several companies: Navegación e Industria, Línea de Vapores Tintoré, Compañía Valenciana de Correos de Africa, Ferret y Peset Hermanos, Compañía Anónima de Vapores Vinuesa, and

Compañía Marítima de Barcelona. Navegación e Industria took the Nuevo Vulcano plant with it into the new firm.

Finally, in 1925, Unión Naval de Levante was incorporated, under the auspices of Krupp. It included the Nuevo Vulcano plant in Barcelona, the Gómez shipyards and factory in Valencia, and the Tarragona shipyards.

### Alexander Hermanos

Two Scottish brothers, David and Thomas Alexander, set up in trade in La Barceloneta under the name Alexander y Hermanos with the intention of building steam engines to compete with Nuevo Vulcano. They looked for partners to raise more capital, but it was not until 1857 that the elder brother, David, founded the firm Font, Alexander y Compañía in partnership with Eusebi Font. The new company opened a factory in the district of El Clot and also set up one of the steelworks referred to earlier, which closed down five years later.<sup>15</sup> Its failure put an end to the brothers’ hopes of supplying raw materials to the factory in La Barceloneta themselves. This would have avoided the difficulty of obtaining supplies of foreign iron and, had they succeeded, would have given them a considerable advantage over their direct competitors, La Maquinista and Nuevo Vulcano. It should also be pointed out that prior to this, in 1852, the brothers had had discussions with Valentí Esparó. One topic, naturally, was steam engines, but another more innovative idea was also on the agenda: that of building locomotives. Esparó, however, preferred to set up his own company and ultimately he joined with other partners to found La Maquinista Terrestre y Marítima.

But to return to Font, Alexander y Compañía, in the very year of its foundation, 1857, the firm built a 32-tonne steam ship called the “Tarragonés”. But just as the owners’ hopes were soaring, the factory in La Barceloneta was destroyed in a spectacular fire that broke out on 20 March 1858 and gutted the entire building. The only item that was saved was the steam engine that supplied energy to the industrial complex, which was situated in an isolated annex. Admittedly, since the next-door building was a brandy warehouse, where large quantities of spirits were stored, the disaster was not a great as it might have been, for the whole neighbourhood could have gone up in flames. The Alexander brothers, in any event, decided on a change of scene and proposed erecting a new building in the district of El Poblenou, between the Mataró railway line and El Bogatell. The proximity to the sea would have made it easy to launch the ships they planned to build, while the site was large enough to isolate the plant from other buildings, safeguarding it from possible outside hazards, and protecting the surrounding area from any danger the factory itself might cause. However, the land was located in a military zone (the second line of defence of La Ciutadella, the fortification built after the War of the Spanish Succession) and a royal permit was necessary. The official application met with a precisely worded refusal:<sup>16</sup>

“The establishment can set itself up in any other spot that does not affect the defences of Barcelona since its

products are not intended for the exclusive use of the city but for the use of the navy in general, wherever they may be required. Thus I am of the opinion that the application should be rejected.”

After their application was turned down, the Alexander brothers decided to stay where they were, an example of the sort of thing that happens in a city under military occupation. They put their shoulders to the wheel and the firm made a rapid recovery: just two years later a 55-tonne ship, the “Catalán”, was built. It was the eighth ship to come out of the Catalan shipyards:<sup>17</sup>

Name	Tonnage (in tonnes)	Year	Shipyard	Shipbuilder
“Primer Catalán”	116	1846	Blanes	Josep Vieta
“Barcelonés”	94	1848	Blanes	Josep Vieta
“Remolcador”	31	1849	Barcelona	Pere Sisteré
“Victoria”	110	1855	Barcelona	Pere Sisteré
“Tarragonés”	32	1857	Barcelona	Alexander
“Montjuich”	30	1857	Barcelona	Maquinista
“Indio”	45	1858	Barcelona	Maquinista
“Catalán”	55	1860	Barcelona	Alexander

The firm put its products on show at the 1860 Barcelona Exposition: steam engines, flour mills, and water pumps for irrigation. During its heyday, around 1884, it had 400 workers on the payroll. Later, though it also began to make water turbines, it started going downhill. By 1882, nevertheless, it had made 1,006 steam engines — its chief product — and six years later, when the Universal Exposition was held, it had produced 1,350, with a total power of 35,000 HP. Another ten years later, on the threshold of the 20th century, there was talk of reaching 1,500. It eventually went into liquidation in 1923.<sup>18</sup>

### La Maquinista Terrestre y Marítima

#### *The Firm’s Foundation*

We will devote rather more space than would be usual in a text of this nature to the foundation of the most important metallurgical firm in Spain because it will give us the opportunity to mention other companies which also played an important role in the Catalan economy at the time.

Between 1839 and 1841 Valentí Esparó decided to extend the factory on Carrer Tallers that bore his name. This made it one of Barcelona’s largest machine manufacturing and repairing establishments, alongside Nuevo Vulcano, and Fundición de Hierro y Taller de Construcción de Maquinaria. Let us pause briefly to consider the origins of the latter company, which was known as La Barcelonesa. It dated from 1838, when Manuel Lerena had bought up the Perrenod factory and then, in partnership with Nicolau Tous i Soler, Joan Güell i Ferrer, Jaume Ricart and Manuel Serra, enlarged and transferred it to the premises of a

former Capuchin convent. From this moment on, La Barcelonesa was a reality. Three years later Celedoni Ascacibar joined the firm, which then became Tous, Ascacibar y Compañía and opened a factory in a former Augustinian convent on Carrer de Sant Pau. It changed its name once more to Fundición de Hierro y Taller de Construcción de Maquinaria — though the nickname La Barcelonesa still endured — and decided to embark seriously on the construction of heavy machinery.

The firm La Maquinista Terrestre y Marítima was born in 1855 out of the partnership between V. Esparó and Tous, Ascacibar y Compañía (or, to put in another way, out of the merger between V. Esparó’s factory and that of Fundición de Hierro, still known as La Barcelonesa). It had a capital of twenty million *reales* divided into 5,000 shares of 4,000 *reales* each. The main shareholders were J. Colomer (1,056 shares), V. Esparó (822), R. Bonaplata (469), N. Tous i Mirapeix (438), J. M. Serra (453), J. Güell i Ferrer (267), J. A. de Mendiguren (200), C. Ascacibar (190), and N. Tous i Soler (170). The firm’s plans were clearly set out in the second of its articles of incorporation:

“The purpose of the firm will be to smelt metals, to build ships, boilers, steam engines for use on land and water, railway locomotives, hydraulic motors, transmissions, spinning machines, machines for woven and printed fabrics, and any other type of machine that may be considered appropriate, using the factories it currently owns or any others which it may set up...”<sup>19</sup>

This statement was a response to the challenges inherent in the industrialization of Catalonia and Spain. However, the building of the railway network soon made it apparent that bridges had been omitted from the list of intentions. Accordingly the company amended its articles in 1870 to include certain sectors — metal buildings and bridges — which had not originally been taken into consideration. In the coming years, as we will soon have an opportunity to see, these very sectors were to account for an important part of its activities.

But before examining the company’s output, it is important to stress that La Maquinista Terrestre y Marítima, Nuevo Vulcano, Alexander Hermanos, and Portilla & White of Seville, were to be the leading heavy machinery manufacturers in the Iberian peninsula. And La Maquinista was to be the biggest of them all.

#### *The Manufacture of Machinery for Ships*

La Maquinista, as stated in its articles of incorporation, started out building ships: the “Montjuich” and the “Indio”.

The “Montjuich” was a tug with an iron hull. It was 76 feet long (23.16 m), with a 14-foot beam (4.26 m) and a depth of 8 feet (2.43 m). The net tonnage was 30 tonnes, it had a 40-HP steam engine, and was entirely built on the firm’s own premises. The owners, Vicent and Jacint Torner, who paid 14,000 *pesos fuertes*, did not get much

service out of it because five years later the boilers exploded and the “Montjuich” sank.

The second ship, the “Indio”, was larger (43.28 m long, 5.63 m wide, and 2.89 m deep). Naturally it was heavier as well: total volume 112 tonnes, cargo, 52 tonnes. It had a 70-HP steam engine and cost the buyers, Gaspar, Roig y Compañía, 36,000 *pesos fuertes*.

After these early experiments, the management of La Maquinista realized that shipbuilding was likely to cause many difficulties and decided to devote their energies exclusively to making and repairing steam engines and boilers for ships (and all the necessary accessories). Shipbuilding activities were left to the shipyards in Northern Spain, located near a major steel industry.

In 1862 the works moved to La Barceloneta. The situation during these early years was dominated by free trade. Though La Maquinista Terrestre y Marítima won several contracts from the Spanish Admiralty, free trade was gradually reinforced — as the 1869 tariffs showed — and the number of government contracts diminished. To weather the crisis, it had to accept many different kinds of orders and this, as we will see, had negative effects. The men of La Maquinista, needless to say, were always stalwart supporters of protectionism.

Following the restoration of the monarchy in 1874, a mild form of protectionism was finally introduced, but it was not until the end of the century that protectionist policies were firmly established. This resulted in a rapid rise in the production of maritime motors at La Maquinista Terrestre y Marítima. Both the law for the construction of a war fleet, passed in January 1887, and the 1906 customs law were beneficial to domestic industry, and thus to La Maquinista as well.

Under the 1887 law the sum of 189,900,000 pesetas<sup>20</sup> was earmarked for the building of new warships. The law also provided for an outlay of 22,600,000 pesetas for completing work already underway and 112,500,000 pesetas for improvements to the arsenals. All in all, 225 million pesetas.

To illustrate the consequences, we will list all the maritime steam engines made by La Maquinista between 1887 and 1892:

The 1907 law, which followed immediately after the introduction of new tariffs the previous year, included a budget for an amount similar to that of the 1887 law, divided out under the same three headings. Between 1887 and 1907, however, lay the ill-fated year of 1898, when Spain lost its last colonies and its fleet played a role that was far from brilliant. The defeat showed that mistakes had been made, and now, in 1907, it was necessary to start all over again, at the same point as in 1887.

To assess the scale of the work carried out at La Maquinista, we will examine, in some detail, the engines and boilers made for the cruiser “Reina Regente”. The hull was under construction in the shipyards in El Ferrol and the specifications for the engines and conditions of delivery were laid down by the ministry in a Royal Order dated December 1906. La Maquinista Terrestre y Marítima responded with a counter-bid of 3,260,000 pesetas but took the liberty of expressing doubts about the Belleville boilers requested by the ministry in the Royal Order. Though Belleville had a good reputation, La Maquinista claimed it lacked experience in the boiler making field and offered to replace the Belleville boilers by other cylindrical, tubular boilers, with an inner furnace and return flue, with which La Maquinista itself had acquired considerable practice. The replacement would have meant a saving of 310,000 pesetas but the ministry did not give way.<sup>21</sup>

The ship was to have two triple-expansion vertical inverted engines; they were to operate at 1,400 rpm and a pressure of 13 Kg/cm<sup>2</sup>; each engine was to rotate an axle equipped with its own propeller; and they were to generate 9,000 HP at natural draught and 11,000 HP at forced draught.<sup>22</sup>

The costs were as follows:

<b>Engines</b>		
Materials		948,318.95 pesetas
Labour		439,339.08 pesetas
Packing and shipping		54,042.55 pesetas
<b>Total</b>		<b>1,441,700.58 pesetas</b>
<b>Belleville boilers</b>		<b>1,004,957.14 pesetas</b>
<b>Total cost</b>		<b>2,446,657.72 pesetas<sup>23</sup></b>

Ship	Year	Engines		Power (HP)		Pesetas
				Natural draught	Forced draught	
“Alfonso XIII”	1888	triple expansion	(horizontal)	7,800	11,500	2,690,000
“Lepanto”	1888	“	“	7,800	11,500	2,690,000
“Ensenada”	1888	“	“	1,600	2,200	460,000
“Yáñez Pinzón”	1891	“	(vertical)	650	2,600	603,000
“P. Asturias”	1891	“	(horizontal)	10,500	15,000	3,675,000
“Cataluña”	1891	“	“	10,500	15,000	3,525,000
“Galicia”	1892	“	(vertical)	650	2,600	500,000
“Cisneros”	1892	“	(horizontal)	10,500	15,000	3,275,000
“Carlos V”	1892	“	“	15,000	18,000	?

The contract was worth 3,260,000 pesetas. Thus the net profits, in this case, amounted to 813,342.28 pesetas, 33 % of the cost price. The operation was profitable. But this was not always the case.

We know that La Maquinista Terrestre y Marítima also made 569 stationary steam engines for use on land, representing a total power of 32,745 HP. Of these, 425 remained in Catalonia. The last one came out of the factory in 1935. If we examine the output by five-year periods, we see that production peaked in the period from 1871 and 1900, the largest number of units (70, with a total power of 3,167 HP) being made between 1871 and 1875. On the other hand, since demand for more powerful engines increased over time, the largest output in terms of power corresponds to the period from 1896 to 1900 (45 units, with a total power of 4,296 HP).<sup>24</sup>

#### *The Bridges built by La Maquinista*

As already mentioned, La Maquinista did not originally anticipate building metal structures. However, the opportunities afforded by the construction of the Spanish railways — which required many bridges to overcome the numerous topographical barriers in the landscape — caused the men in charge of the firm to think again. Thus it came about that in 1870 the articles of association were amended to enable the firm to enter a sector that had not initially been envisaged: that of bridges and other metal structures. Under the latter heading, first mention must go to the El Born market in Barcelona, but La Maquinista also built many more markets in the city, including those of Sant Antoni, Hostafrancs, La Barceloneta, La Concepció and La Llibertat (in Gràcia).

One of its most distinctive buildings was the Estació de França, Barcelona's main railway station, which was built for the 1929 Exposition. It is one of the most original structures of its type, not merely in Spain, but anywhere in Europe.

The experiment that led to the decision to amend the articles of association in 1870 was the building of the firm's first two bridges — the Vall de Gorp and Jalón bridges — in 1868 and 1869 respectively. In 1871, following the re-definition of its sphere of activity, it built twenty-nine bridges and from then until the outbreak of the Civil War in 1936, La Maquinista Terrestre y Marítima erected a total of 739 bridges.<sup>25</sup>

Among the most spectacular were two bascule bridges over the Guadalquivir — the Alfonso XIII (1920) and the San Telmo (1927) — and the bridge of San Juan de Aznalfarache, on the fertile Triana plain.

The most interesting is the San Telmo bridge. To enable ships to pass underneath, it has two central rising leaves, each 25 metres long, and its width — 15 metres — is sufficient for wheeled traffic, a tramway, and a pavement for pedestrians on either side. It takes 90 seconds to raise and 105 seconds to lower.

The longest of all the bridges built by La Maquinista was the eleven-span road bridge over the Ebro in Lo-

groño, which has an overall length of 327.5 metres. The heaviest was the bridge over the Guadalquivir at Alcalá de Guadaíra (1,760 tonnes).

#### *Locomotive Manufacturing*

Throughout the history of La Maquinista, it was industrialization that provided most work for its factories. And the feature of the industrialization process that generated most activity — apart from bridges, which we have already studied in some detail — was the building of the Spanish railways.

Having made that statement, we must now qualify it: though for a long time Catalonia was the main hub of industrialization in Spain, it does not follow that development went ahead smoothly. There were difficulties: not only were the orders few and far between — even when economic development was at its peak, they were relatively scarce — but, to make things even more complicated, they were for a wide variety of items. But these were just two of the problems the men of La Maquinista had to face: other factors that had a decisive impact on the emblematic Barcelona firm were the fact that the railway network was built mainly with foreign capital — and thus the materials came from abroad as well —, the high cost of raw materials, and technological subordination.<sup>26</sup> The firm's management reacted, as mentioned earlier, by appealing constantly for protectionist policies, which were finally implemented towards the end of the century. They also asked the government, time and again, to place orders for as many units as possible, instead of splitting them between several suppliers in an attempt to give each firm an approximately equal share in the budget. It is easy to see that this policy was harmful to specialization, which was the only way economic and industrial development at home could be put on the same footing as in the leading industrial countries, notably England, Germany and France.

The construction of the Spanish railway network began with the Barcelona-Mataró line in 1848 and was complete, broadly speaking, by 1898. It was not until 1883 that La Maquinista produced its first two locomotives. They had been ordered by the Compañía de Tranvías y Ferrocarriles Económicos, which ran the Barcelona-Sant Andreu line. They weighed eight tonnes, had horizontal tubular boilers, and each cost 46,998.65 pesetas to make.

A larger order was for two 42-tonne locomotives to pull coal wagons for the Ferrocarril de Langreo in Gijón. The price, of course, was different: 193,511.69 pesetas, including the boiler. The firm was now beginning to make sizeable engines and its success had opened the doors to a sector which in time was to be of crucial importance to it.

It produced many different models.<sup>27</sup> Model 1.400 weighed 77 tonnes and used re-heated steam. It was inspired by a locomotive known as the 1.300, manufactured by the prestigious firm Hannomag since 1914, which was already in use on the Spanish railways. Then

there were models 1.600 and 1.700 — legendary locomotives which gave surprisingly good results — and a model 1.800 as well. Having found the right product, the firm inaugurated a new locomotive plant in Sant Andreu, Barcelona, in 1920. Here the units under construction were placed one beside the other and groups of specialized workers were moved about in accordance with a careful plan so as to speed up the manufacturing process and make the best possible use of their skills. During this first phase, four of the six sheds planned (9,500 m<sup>2</sup>) were opened.

Another famous locomotive also deserves to be singled out. It was called the Santa Fe, a name highly appropriate to the new era that got underway in the aftermath of the 1936-1939 Civil War.<sup>28</sup> It was a 2-10-2<sup>29</sup> and was designed to haul goods trains over terrain with steep inclines and tight bends. The exact specifications stated that it must be capable of pulling 350 tonnes at a speed of 40 Km/H up a 20: 1,000 incline with bends of a radius of 300 metres.<sup>30</sup>

In order to fulfil its function, the Santa Fe had considerable adhesive weight (105 tonnes). It also had three expansion cylinders, two of which were exterior and horizontal, and the other interior and sloping. Each was equipped with a Walschaerts valve gear. The boiler was 2 m in diameter and nearly 11 m long. The grate was designed in such a way that coal of 7000 Kcal/Kg had to be used. This caused problems because in the post-war years it was not always available. Twenty-two units were built. The Santa Fe was the most powerful locomotive in Europe at the time, apart from the Soviet-built 2-10-4.

Another engine that caused a sensation in its day was the Confederación (4-8-4), built at the time of La Maquinista's centenary. It presented an important new feature: it ran on diesel oil instead of coal, though the process was that of a steam engine since the heat generated was used to produce steam, which expanded in the cylinders. The indicated power was 2,700 CV,<sup>31</sup> the maximum power delivered was 4,226 CV, and it set a new Spanish speed record for steam engines: 135 km/h.

To show what a locomotive cost, we reproduce, in summary form, the price of a 2.700 model made in the 1940s:<sup>32</sup>

Locomotive	1,161,451 pesetas
Labour	1,737,785 "
Tender	497,272 "
<b>Total</b>	<b>3,396,508 "</b>

The last steam locomotive built by La Maquinista was delivered to the RENFE (the Spanish government railways) on 18 April 1961. It was number 721 and was made for the publicly-owned company Calvo Sotelo for use on the line from Andorra to Escatrón in the province of Teruel. Christened "Samper de Calenda", it was a 4-8-4 and remained in service until the 1980s.

In summary, La Maquinista heads the ranking for the number of steam locomotives made in Spain:<sup>33</sup>

La Maquinista Terrestre y Marítima	721
Babcock & Wilcox	523
Euskalduna	341
Devis-MACOSA	143
Sociedad Española de Construcción Naval	26
<b>Total</b>	<b>1,754</b>

Though this list reflects the importance of the Barcelona firm, we must also stress, with all due humility, that the industrialization of Spain was unimpressive in comparison with flagship countries such as Germany. By 1858, for instance, the German firm Borsig had made a thousand locomotives; the eleven thousandth came out of its factories in 1911. Another German firm, Henschel & Sohn, which had also produced 11,000 locomotives by 1911, doubled its production capacity in eleven years.

Thus there is no possible comparison. To each his due.

#### **MATERIAL PARA FERROCARRILES Y CONSTRUCCIONES S.A.**

The firm that bore this name was founded in Barcelona on 23 December 1881. It absorbed another firm — Herreía del Remedio — and the main shareholders, the members of the Girona family, held 37.5 % of the shares. Though the articles of association stated that it was to set up steelworks, it never actually did so. Instead it devoted its efforts almost exclusively to making various items of railway equipment, wagons and coaches being its speciality. It was one of the few Catalan companies that was not led astray by the mirage of diverse orders, and which understood, in other words, that specialization in just a few products was vital to competitiveness. It is significant, in this respect, that when the Dirección General de Comunicaciones issued a call for tender for the construction of sixty two- and three-axle coaches to be used as travelling post-offices, Material para Ferrocarriles y Construcciones S.A. had to compete against several important companies including Neufville from Liverpool and Maschinenbau from Nuremberg.<sup>34</sup> This was in 1892. Winning this contract was an important achievement, despite the fact that the estimate had been low and so the profit margin was slender, if indeed it existed at all. But from then on the firm enjoyed prestige at home and abroad and this brought noteworthy benefits in the long term.

The results of specialization are apparent from the data for 1905: in addition to the 60 coaches made for the Dirección General de Comunicaciones, the firm had produced 604 train wagons and 200 trams. It also built a few

bridges but in 1892 — a key year in its history — it withdrew from this sector.

In the 20th century, Materiales modernized and put two new Siemens furnaces into operation, in 1907 and 1928. By the year of the Barcelona Exposition (1929), it had built over 1,800 wagons.

In 1947, after the Civil War, it merged with Devis S.A. of Valencia. Under the name MACOSA (Material y Construcciones SA), it became one of the foremost factories in Catalonia during this last phase of industrialization, which took place in the 1950s and 1960s.

### Planas, Flaquer y Compañía

Joan Planas i Castañer — who had set up in business in Girona in 1824 — created the metallurgical company Planas, Junoy, Barné y Compañía in 1857. It had a capital of 260,000 *reales* and was to specialize in making turbines. Joan Planas was convinced that hydraulic power was under-utilized in Catalonia and that more benefit should be derived from it: in view of the low efficiency of water wheels, people should turn their attention to turbines, which were beginning to spread throughout Europe. He therefore bought the exclusive rights to the Fontaine turbine, an axial-flow turbine that was very suitable for small waterfalls, and set about making as many of them as he could.<sup>35</sup>

It is worth mentioning that turbines represented a considerable advance over water wheels, since they rotated faster and increased efficiency to almost 90%. The technical improvements, which were strictly practical in nature at the outset, were gradually enhanced with the help of science.<sup>36</sup>

But to return to the company, it put its traditional model on show at the 1871 Exposition — by which time it had changed its name to Planas, Junoy y Compañía — and reported that it had already produced one hundred and fifty units. When Joan Planas i Castañer died, he was succeeded by his son Joan Planas i Escubós, who was an industrial engineer. The son went into partnership with another engineer, Alfons Flaquer, and together they founded Planas, Flaquer y Compañía (1884). With the up-to-date know-how they had acquired at the Escola d'Enginyers de Barcelona, they made improvements to their turbine so that it could compete with foreign imports. They also decided to add other machines to their catalogue (which included turbines, continuous paper machines, grinding mills, etc.) and to direct their efforts towards the manufacture of electrical supplies. The success they achieved in this field would be worth relating, were it not for the fact that this article is confined to heavy machinery.

In any event, between 1858 and 1910, the firm (under its three different names) built 1,212 turbines with a total power of 86,173 CV (an average of 71 CV each).<sup>37</sup> Nearly half were delivered to other parts of Spain and most were purchased by the textile, paper, flour and electricity sectors.

### Mechanical Engineering in the Valencian Country

Having referred to the industrialization of the Valencian Country at the beginning of this article, we will now return there to highlight a few further points.

It is important to recall, in the first place, that the region of Valencia is the least well endowed in underground mineral resources in the entire Iberian peninsula, and in the second place that it was demand from the agricultural sector that lent impetus to mechanical engineering and machine production.

In 1856, 11 firms belonging to the machine manufacturing sector were paying tax in the Valencian Country, as opposed to 84 in Catalonia. By 1900 the numbers were 58 and 725 respectively. It should be noted, however, that not all the firms in the Valencian Country made heavy machinery — some specialized in industrial appliances and light machinery — and that their total power was 70 CV, as opposed to 266 in Catalonia.

Reliable proof that mechanical engineering plants were present in the Valencian Country, though not in large numbers, is provided by the existence of various factories: one in Alcoi belonging to Tomás Aznar y Hermanos; another belonging to two British businessmen, G. Bartle and E. Morris; another under Belgian ownership (A. y J. Donnay y Compañía, known as La Maquinista Belga); and the Alexander brothers' plant, which was in the Valencian Country from 1846 to 1849 before it moved to Barcelona.

Fundición Primitiva Valenciana, set up by Isidre Bofill in 1843, became a major firm and finished up in the hands of Valerio Cases Domingo, a self-made man, trained in Barcelona, who made a meteoric ascent from apprentice to entrepreneur. He had an inborn flair for mechanics and had dreamt from his early youth of building steam engines like the ones made at Alexander y Hermanos. His dream came true, as is shown by the two silver medals he was awarded at the 1876 Centennial Exposition in Philadelphia: one for an iron noria and the other for a steam engine.<sup>38</sup> The next year Fundición Primitiva Valenciana made two Corliss-type steam engines and a small 4 CV road engine, which was probably the first in Spain.

After the death of Valerio Cases, the firm continued under a new name — Viuda e Hijos de Cases S. A. — with his son Ramón, an industrial engineer, at the helm. He went on making small steam engines, but also embarked enthusiastically on the construction of more powerful ones. The result was a 100-CV Corliss, which came out of the factory in 1884. It was made for the Alzucen flour mill, in Ciudad Real, and could grind 20,000 kg of wheat per day using the new Austro-Hungarian system.<sup>39</sup> A more important development was the first locomotive entirely made in the Iberian peninsula, on which the firm started work that same year. It was for use on the line from Barcelona to Sant Joan d'Horta. At the trials that took place on 13 April, it was driven by the painter Ramon Casas.<sup>40</sup>

Another important Valencian firm was the one founded in 1897 by Miquel Devis Pérez, which also specialized in equipment for the Spanish government railways. By

the time it became a limited company in 1929, it occupied premises of 50,000 m<sup>2</sup>, employed 2,000 people, and was about to inaugurate another factory in Alcázar de San Juan. It built five 2-4-0 locomotives in 1932 and three years later produced two more of the same type.

In 1947 it merged with the Barcelona firm Material para Ferrocarriles y Construcciones which, as mentioned above, had a plant that specialized in manufacturing coaches and wagons and, once its Siemens furnaces had been fitted, in producing steel as well. The new company was called Material y Construcciones S.A. (MACOSA) and Construcciones Devis S.A. contributed its plants in Valencia for building and repairing coaches, wagons and locomotives and those in Alcázar de San Juan, which were devoted exclusively to wagons. MACOSA was to become one of the most powerful firms in the sector.<sup>41</sup>

We conclude this section with a brief reference to the boilermakers Felip Genevois and Joan Marco Dolz, whose had premises on Camí Vell de El Grao.

## SUMMARY

The industrialization of Catalonia, a land lacking in coal and iron ore and therefore dependent on the steel industry of Northern Spain, was fraught with obvious contradictions. Despite this, Catalonia and the Basque Country are the only parts of Spain where it is possible to refer to an industrialization process at all. One of the problems was that Spain itself — a backward, agricultural country — was the main customer of the Catalan textile industry. Consequently Catalan industrialization was handicapped by the fact that supply often outpaced demand. These difficulties, unsurprisingly, had more serious effects on the heavy machinery manufacturing sector. Moreover, not only were raw materials more expensive than in other countries — because of the mineral-poor subsoil and the deficient transportation system (railways, roads, etc.) — but major factories (La Maquinista Terrestre y Marítima, Nuevo Vulcano, and others) had to adapt to a situation in which orders were excessively varied and not very numerous.<sup>42</sup> These fluctuations in demand, of course, obliged firms to concentrate on short production lines and consequently to adapt their factories each time the product changed (totally or partially). This inevitably made costs, which were already high because of expensive raw materials, even higher. In short: if machines (looms, spinning machines and locomotives) cost more than they did abroad, this in turn made products (such as thread or transportation) more expensive, and consequently consumers, whose purchasing power was low, did not, and could not, perform their function, which has always been to buy. Thus, apart from situations like the one created by the First World War, which was an exception in the overall panorama we have described, the only factor capable of giving impetus to Catalan industrialization was protectionism, an economic policy rife with inherent defects and problems.

In short: to meet these conditions, Catalan industry's productive capability had to be broadened, and this meant sacrificing quality to diversification in order to find customers. This was the exact opposite of what happened in England.

As for the Valencian County, the gigantic efforts deployed enabled it to become the second most industrialized region in Spain (not counting the Basque Country and Navarre, for reasons already mentioned) in the early 20th century. However, the economic and industrial development of Spain as a whole was both slow and irregular.

## NOTES AND BIBLIOGRAPHY

- [1] P. VILAR. *Catalunya dins l'Espanya Moderna*, 4 vols. Edicions 62, Barcelona 1966; also, by the same author, "La Catalunya industrial: reflexions sobre una arrencada i sobre un destí", *Recerques*, 3, 1974, pp. 7-22. Vicens Vives addressed the topic in Jaume VICENS VIVES and Montserrat LLORENS, *Industrials i polítics del segle XIX*. Teide, Barcelona 1958.
- [2] Jordi MALUQUER DE MOTES published an excellent article on the subject: "La revolució industrial a Catalunya". *L'Avenç*, No. 73, 1984, pp.18-34.
- [3] It should be recalled, however, that between 1804 and 1806 Francesc Santponç had designed and built three steam engines — one Newcomen engine and two Watt engines — at the instigation of Jacint Ramon, a manufacturer of printed calico. The last of these engines, which had a power of 6 HP, served to raise water to drive the water wheels that powered the factory: J. AGUSTÍ. *Ciència i tècnica a Catalunya en el segle XVIII o la introducció de la màquina de vapor*. Barcelona, Institut d'Estudis Catalans, Barcelona 1983.
- [4] Nor should we overlook the industrial villages built along the banks of two Catalan rivers, the Ter and the Llobregat, which used hydraulic power. This topic is dealt with in two very important monographs: I. TERRADAS SABORIT. *Les colònies industrials. Un estudi del cas de l'Ametlla de Merola*. Editorial Laia, Barcelona 1979 (an enlarged and revised edition was published later: T. TERRADAS. *La qüestió de les colònies industrials. L'exemple de l'Ametlla de Merola*. Centre d'Estudis del Bages, Manresa 1994). Gràcia DOREL-FERRÉ. *Les colònies industrials a Catalunya. El cas de la colònia Sedó*. Publicacions de l'Abadia de Montserrat, Barcelona 1992.
- [5] Some have observed that, while the industrialization of Catalonia unquestionably received a definitive impulse between 1830 and 1860, its contribution to the growth of Spain's gross domestic product was slight: J. R. ROSÉS. "Industrialización regional sin crecimiento nacional: la industrialización cata-

- lana y el crecimiento de la economía española (1830-1860)". *Revista de Historia Industrial*, 25 (2002), pp. 49-79.
- [6] Jordi NADAL. "El desarrollo de la economía valenciana en la segunda mitad del siglo XIX: ¿una vía exclusivamente agraria?" in Jordi NADAL, Albert CARRERAS (Eds.). *Pautas regionales de la industrialización española (siglos XIX y XX)*. Ariel, Barcelona (1990), pp. 296-314.
- [7] J. NADAL, A. CARRERAS, *op. cit.* (1990), p. 298-299.
- [8] Catalonia had a reputation for high-quality iron (and even steel, known at the time as *ferro bo*, 'good iron'). A specific native process, handed down from generation to generation, was used to produce it and the Catalan iron industry was known as *la farga*. To understand how the method worked, see: P. MOLERA I SOLÀ. *La farga*. Barcelona, series "Conèixer Catalunya", No. 29. Dopesa, Barcelona 1980. A revised, enlarged edition of this book came out three years later: P. MOLERA, C. BARRUECO I JAOUËL. *Llibre de la farga*. Barcelona, series "Nissaga", No. 1. Rafael Dalmau editor, Barcelona 1983. An exhaustive economic study of three ironworks in the Pallars Sobirà region has also been published: C. MAS. *Història de la farga catalane*. Pagès editors, Lleida 2000.
- [9] J. NADAL. *Moler, tejer y fundir*. Ariel, Barcelona 1992, pp. 144-146. The first part of this book reproduces texts from the catalogue to the exhibition *Catalunya la fàbrica d'Espanya, 1833-1936*, staged at the El Born market in 1985.
- [10] The expression 'Northern Spain', used several times in this article, refers to the area west of the Pyrenees, primarily the Basque Country, Asturias and Galicia, and therefore does not include Catalonia.
- [11] J. CARRERA I PUJAL claims that a plant bearing this name had existed since 1826 but it has not been possible to prove this: J. CARRERA PUJAL. *La economía de Catalunya en el siglo XIX*, Vol. IV. Bosch, Barcelona 1961, p. 26.
- [12] *Navegación e Industria. Pactos y condiciones de la contrata de dicha Sociedad Anónima establecida en Barcelona por acciones de 5.000 rs una. Reglamento de la misma; aprobados unos y otros por el tribunal de comercio de dicha plaza*, Barcelona, Imprenta de A. Brusi, 1842, III, p. 4, Arxiu Històric de la Ciutat de Barcelona.
- [13] The capital of Navegación e Industria (864 shares of 5,000 *reales* each, or a total of 4,320,000 *reales*) was initially divided up as follows: J. Reynals, 181 shares; J. Vilardaga, 107 shares; J. Castañer, F. Broca, I. Villavecchia and Girona Hermanos Clavé y Compañía, 144 shares each. In 1843 new shareholders entered the company — J.M. Serra, J. Safort, J. Plandolit and R. Vieta — as well as shareholders from other port cities and from Madrid. Their arrival increased the capital to 7,500,000 *reales*. See: Santiago RIERA I TUÈBOLS. *Dels velers als vapors*. Associació d'Enginyers de Catalunya, Barcelona 1993, pp. 176-181.
- [14] The actual steam engine designed by White was made in the factory of Valentí Esparó, while the boilers were made by Nuevo Vulcano, and the hull, as stated in the text, was made in the shipyards of Pere Sisteré. See: S. RIERA I TUÈBOLS. *Dels velers als vapors*, *op. cit.* pp. 183-184, and Note 61 on page 184.
- [15] Carreras Pujal tells us that when the furnace commenced operation, the event drew much attention in the city. A report published in *El Diario de Barcelona* remarked that the site (in El Clot) was "extremely advantageous [...], because one day it will put it in fast, direct communication with the coal fields at San Juan de las Abadesas". J. CARRERAS PUJAL. *La economía de Cataluña en el siglo XIX*, II. Barcelona, Bosch, Barcelona 1961, p. 389.
- [16] J. NADAL, X. TAFUNELL. *Sant Martí de Provençals, pulmó industrial de Barcelona (1847-1992)*. Barcelona, Columna, Barcelona 1992, p. 30-34, where the complete response to the application can be found.
- [17] J. RICART GIRAL. "El siglo de oro de la marina veletera de construcción catalana". *Memorias de la Real Academia de Ciencias y Artes de Barcelona*. López Robert y Compañía, Barcelona (1924), p. 25. These results were very meagre, owing to the lack of minerals in the Catalan subsoil, which explains why the steel industry, and consequently the shipyards as well, moved to Northern Spain.
- [18] S. RIERA I TUÈBOLS. *op. cit.* (1993), pp.185-188.
- [19] *Contrata social, Estatutos y Reglamentos de la Compañía Anónima "La Maquinista Terrestre y Marítima"*. Arxiu Nacional de Catalunya, Inv. 77, UI 11. Art. 2º.
- [20] We give the amounts in pesetas, as they appeared in contemporary documents.
- [21] This is stated in *Escritura de contrata de construcción de las máquinas para el crucero "Reina Regente" otorgada por La Maquinista Terrestre y Marítima de Barcelona...* Madrid, Imprenta del Ministerio de Marina, 1898, p. 2, Arxiu Nacional de Catalunya, Inventory No. 77, Ref. 2.06.22/48-2/2.
- [22] *Especificaciones de máquinas de 9.100 caballos indicados tiro natural y 11.000 caballos indicados tiro forzado para el nuevo crucero "Reina Regente"*, undated, p. 2, Inventory No. 77, Ref. 2.06.22/43-1/2.
- [23] *Libro de Recopilaciones de Trabajos de Marina (1897-1902)*, pp. 271-353, Arxiu Nacional de Catalunya.
- [24] Data taken from J. NADAL. "La metal·lúrgia" in J. NADAL, J. MALUQUER DE MOTES, C. SUDRIÀ, F. CABANA. *Història Econòmica de la Catalunya Contemporània*, Vol. 3, *Indústria, transports i finances*. Enciclopèdia Catalana, Barcelona 1991.
- [25] *La Maquinista Terrestre y Marítima (1856-1944)*,

- Barcelona, La Maquinista, undated. Also, A. PÉREZ NÚÑEZ. *Ponts per a una nova època. Els ponts de ferro de la Maquinista Terrestre y Marítima, 1868-1900*, Universitat de Barcelona, unpublished second-year doctoral memoir, 2000-2001 academic year.
- [26] See P. PASQUAL I DOMÈNECH. *Los caminos de la era industrial. La construcción y financiación de la Red Ferroviaria Catalana (1843-1898)*. Edicions de la Universitat de Barcelona, Barcelona 1999.
- [27] For a detailed list of locomotives, see S. RIERA I TUÈBOLS. *Quan el vapor movia els trens*. Enginyers Industrials de Catalunya/Marcombo, Barcelona 1998, especially Chapter IV.
- [28] The literal meaning of Santa Fe is 'holy faith'. It was appropriate because of the militant Catholicism of the Franco dictatorship.
- [29] The formula means: one idle front axle (with two wheels, naturally), five powered axles (live or coupled), and an idle rear axle.
- [30] See: *Caminos de hierro del Norte de España. Locomotoras 2-10-2. Memoria descriptiva i cálculos justificativos*, Inventory No. 77, Dossier 2,329, Arxiu Nacional de Catalunya.
- [31] Power was initially measured in horsepower (HP). Later on this unit was replaced in Europe by CV (*cheval-vapeur*). The two are very similar, however: 1 HP = 1.0146 CV.
- [32] *Locomotoras 4-8-2 para los Ferrocarriles del estado de Chile. Estudio de precio partiendo del de las locomotoras 1.701-25 de MZA*, Inventory No. 77, Dossier No. 2,587, Arxiu Nacional de Catalunya.
- [33] S. RIERA TUÈBOLS, *op. cit.* (1998), pp. 247-249.
- [34] See FRANCESC CABANA. *Fàbriques i empresaris. Els protagonistes de la revolució industrial a Catalunya*. Vol. I. Enciclopèdia Catalana, Barcelona 1992, pp. 88-97. This very useful work consists of four volumes: the first is devoted to the metallurgical and chemical sector; the second to the cotton sector; the third to the wool, silk, knitwear, jute and textile finishing sectors; and the fourth to the graphic arts, paper, cement, construction materials, food, cork and leather sectors.
- [35] See Jordi NADAL. "Los Planas, constructores de turbinas y material eléctrico (1858-1949)". *Revista de Historia Industrial*, N.º. 1, (1992), pp. 63-93, which underlines and explains the importance of Planas turbines in the industrialization of Spain. Also F. CABANA. *op. cit.* (1992), Vol. 1, and J. NADAL, J. MALUQUER DE MOTES, C. SUDRIÀ, F. CABANA. *op. cit.* (1991), pp. 178-183.
- [36] More information about turbines can be found in any of the numerous works on the history of technology. We will give just one reference: B.GILLE. *Histoire des Techniques*. Gallimard, Paris 1968.
- [37] Data taken from J. NADAL, J. MALUQUER, C. SUDRIÀ, F. CABANA. *op. cit.* (1991), p. 181.
- [38] Jordi NADAL. "El desarrollo de la economía valenciana en la segunda mitad del siglo XIX: ¿una vía exclusivamente agraria?" in J. Nadal; A. Carreras. *op. cit.* (1990), especially pp. 302-305.
- [39] A more up-to-date system in which millstones were replaced by rollers.
- [40] This was the first locomotive entirely built in Spain. A few months later La Maquinista Terrestre y Marítima built its own first locomotive (the second in Spain) for the train and tram line from Barcelona to Sant Andreu del Palomar. It should be pointed out that certain authors have considered that the first two engines were those built in the Barcelona factory of the Barcelona-Mataró railway under the supervision of the British engineer White, but these locomotives were assembled there, rather than built from scratch. J. M. ALONSO VIGUERAS. *La ingeniería industrial española en el siglo XX*. Madrid 1944, pp. 128-129. The author specifies the locomotive's technical characteristics.
- [41] F. CAYON, M. MUÑOZ RUBIO. "¿Que fabriquen ellos! La fabricación de locomotoras de vapor en España: ¿una ocasión perdida para la industria?". *Working Papers in Economic History*, No. 2005/02, <http://ideas.repec.org/p/uam/wpapeh/200502.html>. Also M. MUÑOZ. *RENFE (1941-1991). Medio siglo de ferrocarril público*. Fundación de los Ferrocarriles Españoles/ Ediciones Luna, Madrid 1995. On Devis, see M. DEL ÁLAMO ANDRÉS. "Constructores ferroviarios valencianos. Construcciones Devis S.A. (1929-1947) y Material y Construcciones S.A. (1947-1989)" in F.J. OLIVARES, M. MUÑOZ RUBIO, J. SANZ FERNÁNDEZ. *Siglo y medio del ferrocarril en España, 1848-1998, economía, industria y sociedad*, Instituto Alicantino Juan-Gil Albert, Alicante 1999, pp. 809-828.
- [42] The firms referred to in the article were not, of course, the only ones that experienced these difficulties. Another example was Arsenal Civil de Barcelona. Alejandro Wohlguemuth, a Belgian civil engineer, moved to Barcelona around 1870 and opened a machine manufacturing plant. After the 1886 law for the construction of the Spanish fleet was passed, he received an order for three sets of boilers and thought he was made. The order enabled him to build the first of the three buildings that were to house Arsenal Civil de Barcelona on the seafront at Can Tunis. However, the only order he received after this was for a small steam engine for the "Condor". To remain in business, he had to accept other orders: one was to build the monument to Christopher Columbus, another for a group of sculptures to adorn the waterfall in the Parc de la Ciutadella. A bit later, however, Compañía Trasatlántica commissioned him to make the engines for the "Joaquín de Piélagos" and, as a result of these contacts, bought the factory and

founded Arsenal Civil de Barcelona (11 November 1891) with a capital 1,250,000 pesetas. The founding partners were Compañía Trasatlántica and Claudio López Bru, the second Marquis of Comillas (who was also the chairman of Compañía Trasatlántica). But the usual difficulties soon arose: there were not sufficient orders and it became nec-

essary to diversify. Arsenal Civil did not last long and on 23 March 1905 the shareholders decided to halt production and wind up the company. M. RODRIGO, "La industria de construcciones mecánicas en Cataluña: el Arsenal Civil de Barcelona". *Revista de Historia Industrial*, No. 16, 1999, pp. 163-176.

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