Richards and José Antonio de Ybarra Arregui formed the technical tandem for the transfer of processes and techniques into Altos Hornos de Bilbao. Ybarra usually considered the convenience of new technology together with the factory director and presented their projects to the board, in a second phase the board asked Richards for an opinion on the item in question. Richards proposed the optimal solution for the factory given their necessities, their capacity and their demand structure. He put the board in contact with the corresponding machine builder or designing engineer, provided or recommended the British staff for initial operation and training or contracted fulltime foreign technicians for the mill.[i]

Very few of these technologies were obtained via patent application. For the last two decades of the nineteenth century the processes we find patents for Bessemer converters, the Cowper stoves, Siemens and Martin open hearths and by-product coking ovens. But most of the technology is embodied either in machinery or installation design or foreign operators or both. This is reflected to some extent in the high wages perceived by the foreign technicians we have recorded in the case of Altos Hornos de Bilbao in table 4. An extreme example of this is the case of Altos Hornos de Bilbao's first manager, Alexandre Pourcel.

As we commented earlier, the board of directors had decided to contract a separate engineer for running the new installations. The most important task for this engineer was blast furnace management. The pig iron quality of the new blast furnaces had to comply with the exact specifications required for the Bessemer converters, so that liquid pig iron could flow out of the blast furnace into a ladle and be poured into the preheated converters for steel processing. Alexandre Pourcel, the previous manager of the Terre Noire works in France brought along such qualifications. He was an experimented engineer with an important reputation for innovative steel making processes at that time. His salary reflects his qualifications and reputation, it was 280 times that of a day wage worker or 75 time that of the following foreign technical manager employed at that time.

Pourcel remained as manager for four years until the end of 1886, the year Bessemer processing began and was replaced by a Spanish engineer, Enrique Disdier Crooke who had been in charge of the Bessemer shop since its construction. Once Bessemer steel processing was working perhaps the directors of the company decided to do without his services. There is no evidence as to what produced his destitution. His successor started with an annual salary which was 36 times less than his, about 8 times that of a day work laborer's.

The modern installations maintained a high presence of foreign technicians, specifically in those areas which required a high degree of diagnostic skills, such as blast furnace management, rolling mills, Siemens furnaces and the tube foundry shop. Even so the Bessemer shop had a qualified work force which had acquired skills since 1856 and on many occasions it was sufficient to have foreign staff for a short training period before turning operations over to the national counterparts.[ii]

The conclusions for technical transfer in steel processing plants is not much different from the previous mechanisms of transfer. Foreign trained engineers and foreign consultants determined the items to be transferred, there was a call for bids from various foreign firms, machine factories or designing engineers considered, the process or installation was brought to Spain with technical supervision from the constructing or designing firm, foreign staff was hired during a training period

or contracted if their specific diagnostic skills were required over longer periods. Tomás de Zubiría e Ybarra was to carry on the tradition of Vilallonga and José Antonio Ybarra. He studied engineering at the University of Liege and substituted his great-uncle and uncle as top technical advisor and director of the board of Altos Hornos de Vizcaya —the merger between the Sestao and Baracaldo factories— from 1902 to 1936. He also became director of the board of the biggest Spanish shipbuilding company in 1909.

*Modern shipbuilding*

There are two origins of modern Spanish shipyards, the promotion of the industry for defence reasons by the state through naval construction plans and the necessity to provide logistical support and construction facilities to shipping companies. The naval construction plan of 1887 opened licitation for three 7,000 t cruisers to be built and fitted out by a Spanish shipyard. Astilleros del Nervion established in 1888 in Bilbao and Vea-Murguía created in 1891 are companies which were created to this end. The second naval construction plan in 1908 was the origin of the Sociedad Española de Construcción Naval. The other two modern shipyards responded to the repair and construction demand created by shipping companies, Matagorda was fitted for repairs in 1878 and for construction in 1890 for the Compañía Transatlántica and Euskalduna was floated for repairs and construction in 1900 for Sota y Aznar.

The fixed capital installations in all of these cases were provided by foreign engineers and firms. Table 5 gives a short summary. The shipyards linked to Naval construction plans formed joint ventures with British enterprises to obtain a regular flow of technology: Palmers, Vickers & Maxim, Whitworth Armstrong and Brown. Euskalduna did not opt for foreign technical guarentee, it acquired machinery, tools, steel and ancillary equipment through the shipping offices Sota y Aznar had in London and Duisburg, and shipped them to Bilbao with their own fleet.[iii]

Vickers & Maxim's participation in the Sociedad Española de Construcción Naval, which was to become the largest shipbuilding company for both civilian and naval constructions, strained technological dependency to an extreme. Vickers limited the transfer of technology to second generation blue prints, it retained a high percentage of the companies profits through technical advisory fees, maintained an important flow of parts from Great Britain to Spain with the corresponding surcharge. As a reaction to this, the growing economic nationalism in Spain and new generations of Naval engineers which attained intermediate management positions within the company in the 1920's forced a growing ISI policy on its production.[iv]

Table 5. *Foreign technical assistance in shipbuilding*

Cádiz

| | |
|---|---|
| 1840 | Thomas Haynes – English engineer establishes ship repair yard in Cádiz and launches first steamship in the 1850's. |
| 1869 | Andrew Patterson and George Taylor machinists at the heaving up slip **,** Empresa Gaditana del Trocadoro, Cádiz. |
| 1872-79 | Robert Bruce Bell and Daniel Miller design and supervise construction of dry dock in Matagorda, Cádiz. [Alexander Lister delegate engineer – Eduardo Pelayo local engineer]. Machinery for dry dock almost exclusively British. |

1889-90 English engineer Walker designs slipway and shops for naval construction in Matagorda, Cádiz. Machinery almost exclusively British.

1890-92 Lobnitz & Cº design and supervise Matagorda's first construction (5 % fee). Thomas Coleman construction director.

1898 Participation of Vickers Sons and Maxim Cº Ltd. and MTM in Constructora Naval Española. Projects, technology and armament in exchange for royalties.

Bilbao, El Ferrol & Cartagena

1888 Astilleros de Nervión, Bilbao. Joint venture for Navy construction plan: Martínez de las Rivas with Charles M. Palmer of Palmer's Shipbuilding and Steelworks at Jarrow upon Tyne. (12 – 15 % foreign labour).

1902 Dry dock Euskalduna projected by Diss & Cº, Düsseldorf.

1908 Sociedad Española de Construcción Naval [SECN]. Joint venture for 2nd Navy Construction Plan: Basque and Catalán banking, steelmaking and shipping capitalists with Vickers Sons & Maxim Ltd, John Brown & Cº Ltd. and Sir W.G. Armstrong Witworth & Cº Ltd. – Archibald J. Campbell as works director and as H.J. Spiers machinery director. Technical advisory office in London.

1908-14 SECN - El Ferrol. Dry dock and dock – Sir J.Jackson & Cº Ltd.

1909-13 SECN – El Ferrol & Cartagena. 50% of all foremen British in 1909, 90% of all managers and foremen in 1912, 63 % in 1913. A drop from 95 to 42 British citizen working at both between 1913 and 1915.

1915 SECN – New shipyard Sestao. Director Alexander Murray. Hires an important number of foreign technicians for key positions and acquires compromise to replace them with indigenous workers.

Sources: Romero González (1996), pp. 63, 82, 164-5, 184; Houpt and Ortiz-Vilajos (1998), pp. 64, 82.

*Conclusions*

We can draw similar conclusions for iron and steel industry. We find that the initiative for bringing British iron processing practices to Spain came mainly from merchant capitals —Heredias, Ybarras—, or foreign entrepreneurs trying to establish operations in Spain. The transmission of coke blast furnaces techniques took place primarily due to one single key figure, Francisco Antonio Elorza. Elorza brought sufficient skills back from Belgium, France, Germany and Great Britain to put coke blast furnace technology in place in Asturias. Even so his first attempts to use coal in Andalusia had failed. The early blast furnaces in Spain were designed and constructed either by Elorza or British and French technicians, and the remaining furnaces not constructed by Elorza were put in place by foreign engineers.

We have very little to base the transmission of puddling and rolling techniques on. The Heredias took out patents for puddling furnaces. They received technical personnel from Bristol. We do have evidence to metallurgic workmen migration in Spain similar to that described by Fremdling for puddler craftsmen. But we have no direct evidence of how these technologies reached Spain and how they were transmitted.

A fact, which is surprising, given Spain's backwardness in terms of income per person and in terms of industrial or economic development during this period, is the high speed of adopting these new technologies. Spanish entrepreneurs were well connected to the European iron circuit.

Within the continental pattern of technological transfer —puddling and rolling first— Spain's lag at adopting new technologies is minimal.

The conclusions for technical transfer in steel processing plants are not much different from the previous mechanisms of transfer. Foreign trained engineers, José Antonio de Ybarra, Victor and Benigno Chávarri, and foreign consultants determined the items to be transferred; this was combined with a call for bids from the various foreign firms, machine factories or designing engineers considered; the process or installation was brought to Spain with technical supervision from the constructing or designing firm; foreign staff was hired during a training period or contracted if their specific diagnostic skills were required over longer periods. Tomás de Zubiría e Ybarra was to carry on the tradition of Vilallonga and José Antonio de Ybarra. He studied engineering at the University of Liege and substituted uncles as top technical advisor and director of the board of Altos Hornos de Vizcaya —the merger between the Sestao and Baracaldo factories— from 1902 to 1936. He also became director of the board of the biggest Spanish shipbuilding company in 1909.

Shipbuilding technological transfer had a different nature. Perhaps the origin of its main transfer mode can be found in the nature of shipbuilding in Spain. The incipient industry had little industrial fiber to base its supply of raw material, machinery, tools, motors and design on. Increasing economic nationalism and the rapid rates of change especially in the armament industry required foreign technical guarantee mechanisms. Joint ventures seemed the safest way to guarantee a continuous flow of technology. As these companies suffered the discrimination of obsolete technology transfer and the repatriation of profits via intermediate components they opted for a process of import substitution industrialization.

**Bibliography**

Adaro Magro, Luis (1985), *Informe sobre el carbón y el estado de la Marina de Guerra*, Oviedo.

Adaro Ruiz-Falcó, Luis (1968), *175 años de la sidero-metalurgia asturiana*, Gijón: Cámara de Comercio, Industria y Navegación.

Altos Hornos de Vizcaya (1902), *Escritura pública de constitución de la Sociedad Altos Hornos de Vizcaya*, Bilbao: Casa de la Misericordia.

Alzola y Minondo, Pablo (1896), *Memoria relativa al estado de la siderurgia en España*, Bilbao.

Bahamonde Magro, A. and L. E. Otero Carvajal (1989), "La reproducción patrimonial de la elite burguesa madrileña en la Restauración. El caso de Francisco de Rivas y Ubieta, marqués de Mudela. 1834-1882." in *La Sociedad Madrileña durante la Restauración, 1876-1931,* Vol. I. Madrid: Alfóz.

Ballestero (1993), *Juan Antonio Suances, 1891-1977. La política industrial de la posguerra.* Madrid: LID.

Chandler, Alfred D. (1990), Scale and Scope: The Dynamics of Industrial Capitalism. Cambridge, Mass.: Belknap.

Díaz Morlan, Pablo (1999), "Los Ybarra Vizcaínos: origen y expansión de una dinastía empresarial (1801-1890)", Documento de Trabajo # 9908, Programa de Historia Económica, Fundación Empresa Pública, Madrid.

Dye, Alan and Francesco Galassi (1995), "Paternalism and Protection: The Institutional Response of the European Periphery to Industrialization," in Pablo Martin Acena and James Simpson (eds.) *The economic development of Spain since 1870*. Elgar Reference Collection. *Economic Development of Modern Europe since 1870*, vol. 6. Aldershot, U.K.: Elgar;, pp. 66-86.

Escudero, Antonio (1998), *Minería e industrialización de Vizcaya.* Barcelona: Grijalbo.

Fernández de Pinedo, Emiliano (1985), "Avances técnicos y consecuencias económicas en la siderurgia española del siglo XX," in J.L. Peset (ed.), *La Ciencia Moderna y el Nuevo Mundo*, Madrid.

Fernández Penedo, Salvador (1964), "Notas para la historia de la siderurgia española. Trubia: los primeros hornos altos de coque y la primera acería de España," *Instituto de Hierro y Acero*, 17 (93), pp. 444-67.

Fraile, Pedro (1992), "The difusión of modern iron and steel technology in France, Spain and Italy" Working Paper No. 92-18, Universidad Carlos III Madrid.

Fremdling, Rainer (2000), "Transfer Patterns of British technology to the Continent: The case of the iron industry," *European Review of Economic History*, 4 (2), pp. 195-222.

---------- (1991), "The Puddler: a craftsman's skill and the spread of new technology in Belgium, France and Germany," *Journal of European Economic History*, 20, pp. 345-374.

Galassi, Francesco (2001), "Measuring social capital: Culture as an explanation of Italy's economic dualism," European Review of Economic History, 5 (1), pp. 29 – 59.

Houpt, Stefan (1998), "Cambio técnico y localización en la siderurgia española integrada, 1882-1936", PhD thesis, Universidad Carlos III Madrid.

Houpt, Stefan and José María Ortiz-Villajos (1998), Astilleros Españoles, 1872-1998. La construcción naval en España. Madrid: LID.

Landes, David (1979), *Progreso tecnológico y revolución industrial*, Madrid: Tecnos.

Montero, Manuel (1995), *La california del hierro*, Bilbao: Dachao.

---------- (1990), *Banqueros, mineros y navieros*. Lejona: Universidad del País Vasco,

Nadal, Jordi (1989) *El fracaso de la revolución industrial en España*. Barcelona: Ariel.

---------- (1970) “Los comienzos de la industrialización española (1832-1868): la industria siderurgica.”in Pedro Schwartz (ed.) *Ensayos sobre la economía española a mediados del siglo XIX*. Madrid: Banco de España.

---------- (1970a), “La economía española, 1829-1931.” in *El Banco de España. Una historia económica.* Madrid: Banco de España.

Niziol, Simon (1996), “British Technologies and European Development 1770-1870. New Perspectives on Technology Transfer”, Paper presented at the 1st European Summer School Montecatini, Italy.

Nuwer, Michael (1988), “From Batch to Flow: Production Technology and Work-Force Skills in the Steel Industry, 1880-1920,” in *Technology and Culture*, pp. 808-838.

Ojeda, Germán (1985), *Asturias en la industrialización española, 1833-1907*. Madrid: Siglo XXI.

Raveux, Olivier (1994), “El papel de los técnicos ingleses in la industria metalúrgica y mecánica del norte del Mediterráneo (1835-1875): una primera aproximación,” *Revista de Historia Industrial*, 6, pp. 143-161.

Romero González, Jesús (1996), “Matagorda, 1870-1940. La construcción naval española contemporánea,” PhD. Thesis, Universidad de Cádiz.

Sánchez Ramos, Francisco (1945), *La economía siderúrgica española.* Madrid: Instituto de Economía Sancho de Moncada.

Söderlund, E.F. (1960) “The Impact of the British Industrial Revolution on the Swedish Iron Industry,” in L.S. Pressnell (ed.), *Studies in the Industrial Revolution*.

Tortella, Gabriel (1994), *El desarrollo de la España contemporánea: historia económica de los siglos XIX y XX*. Madrid: Alianza.

Uriarte Ayo, Rafael (1998), “Desarrollo científico y cambio técnico en la siderurgia vasca del siglo XIX: las experiencias Chenot, Tourangin y Gurlt,” *Llull* 21, pp. 779 – 800.

Wengenroth, Ulrich (1998), “Auslandsinvestitionen der deutschen Schwerindustrie zur Sicherung ihrer Erzversorgung zwischen Gründerjahren und Welwirtschaftskrise.” Working Paper. Munich Center for the History of Science and Technology, November 1998.

---------- (1986), *Unternehmensstrategien und Technischer Fortschritt*. London: Vandenhoeck & Ruprecht, English translation: (1994), *Enterprise and technology: the German and British steel industries, 1865-1895*. Cambridge: Cambridge University Press.

[i] MboD AHB, Vol. I, pp. 25-6, 31, 129, and 177; Vol. II, pp. 54-55, 80, and 126; Vol. III, pp. 42-3, 59, 157, and 171; Vol. VIII, pp. 2, 6, 55; Vol. IX, p. 236.

[ii] Disdier and Sempan took over the management of the Bessemer shop with a visit by Disdier to the major Bessemer mills in Great Britain and a 3 month training period with the Eston Bessemer master. MboD AHB, Vol. I, p. 129.

[iii] Houpt and Ortiz-Villajos (1998), pp. 84-6 and 94n. Euskalduna contracted with a variety of European firms: Central Marine Engines Works (West Hartlepool), Davis & Co. (Suffolk), Blair & Co. (Stockton on Tees), and the Dutch company Wilton's Engineering & Shipway Co. (Rotterdam) were the more important suppliers. Other purveyors included Emerson Walker & Thomson Bros. Ltd. (Dunston) for machinery, John MacDonald & Co. (Glasgow) for tools, Gebr. Stork & Co (Holland) for machines, AB Man Sievert (Stockholm) for tools, Consett Iron Co. (Newcastle) for steel plates and bars, Kinhorn's Valves, John Lynn & Co. for rudders, Clarke Chapman & Co. for cablestoppers, cylinders and fans, Catto Mather & Co for iron plates, Galloways Ltd. (Manchester) for tubes, Stewartes & Lloyds (Birmingham) for tubes, Lancashire Dynamo & Motor Co. Ltd. (Manchester) for engines and others more.

[iv] Houpt and Ortiz-Villajos(1998), p. 135. The Academia de Ingenieros y Maquinistas de la Armada in El Ferrol was reopened in 1914, 18 years after being shut down. Some of future captains of Spanish corporative capitalism were in its first promotion: Juan Antonio Suances, Aureo Fernández Ávila, and Jesús Alfaro Fournier.