Comparative Perspective upon the Introduction of Western Steamship Technology to Japan and China

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1. INTRODUCTION

The water-wheel had been in use for approximately two thousand years when in 1712 Thomas Newcomen designed a steam engine to recirculate water over the water-wheel, and thus increase its effectivity [WHITE 1964: 80f]. The separate condenser invented by James Watt in 1769 proved more efficient than the Newcomen engines, and Watt's invention of the sun and planet gear in 1782 and of parallel motion in 1784 solved the problem of creating rotary motion. In 1770 Watt had already suggested the use of the steam-engine for propelling canal-boats.[1] The development of steam-powered boats progressed rapidly. In 1789 William Symington (1763–1831) first tried a steam-boat on a Scottish canal, and in 1801 he applied a direct-acting steam engine to the propulsion of a tug-boat on the Forth and Clyde Canal [SINGER AND HOLMYARD 1958: 196, 571]. In 1803 Robert Fulton (1765–1815) introduced a steamer on the Seine above Paris, and in 1807 his steamboat the *Clermont* sailed from New York to Albany. In 1809 the *Phoenix* became the first steamship to venture out onto the open sea, in 1816 the first crossing of the Dover Straits was made by a steamship, and three years later the *Savannah* crossed the Atlantic Ocean in 26 days.[2] In 1825 the *Enterprise* reached India, and in 1838 regular steamer crossings of the Atlantic Ocean, the trip taking

1) The suggestion is found in a letter written on 30 September 1770, to which Watt appended a rough sketch of a screw-propeller; see Carnegie [1934: 58].

seventeen days, were inaugurated.

At this time, ocean-going steamships were still fully rigged since steam-engines were as yet unreliable and had not gained the confidence of the majority of naval men. Similarly, iron construction was viewed with distrust by traditional sailors. However, its use in steamers was suggested by the fact that an iron hull lessened the risk of fire and better withstood the vibration of the steam-engine. Its use was further emphasized by the invention in 1822 by General Henri Paixhans (1783–1854) of shells that could be fired from ships in naval engagements [SINGER AND HOLMYARD 1958: 588–589].

Steamship technology was thus a thoroughly new technology, in some respects still unproven in the West, when it reached China and Japan in the mid-nineteenth century. In this respect it was quite unlike other branches of Western science and technology, such as astronomy, mathematics, medicine, materia medica and ordnance, that had been introduced to China and Japan from the early seventeenth century onwards. Steamship technology was still in a transitional phase, with the result that new developments could rapidly render earlier marvels out-dated. For example, the iron-clad *H.M.S. Warrior* which "when put in commission (in 1861) could have taken on the navies of the world single-handed", was obsolete and retired from service in 1884 [SINGER AND HOLMYARD 1958: 589]. Similarly, Isambard Kingdom Brunel's steamship *The Great Eastern,* the biggest ship at 22,500 tons ever built in the nineteenth century, which was launched in 1858, was retired after only fourteen years and scrapped in 1889.

While traditional ship-building technology obviously had a long history in both China and Japan, steamship technology was most certainly a 'new kind of knowledge'. An observation made by Chateaubriand (1768–1848) in *Les Mémoires d'Outre-Tombe,* although in reference to another context, aptly fits the situation in which the two non-industrialized nations found themselves: "L'invasion des idées a succedé à l'invasion des barbares. La civilization actuelle décompassée se perde en elle même"[3] Japan's success in assimilating the 'invasion of ideas' was founded upon the recognition in some sections of the ruling *samurai* class of the over-riding importance of the acquisition of western scientific knowledge.[4] In China, while such a recognition was not entirely lacking, it was qualified by the notion of China as the unique centre of civilization, a notion which was incompatible with a ready

2) It should be noted with regard to this voyage that the *Savannah* in fact made considerable use of sail power, and used its steam-engines only for about three hours per day; see Freuchen [1957: 166].

3) "The invasion of barbarians has given place to the invasion of ideas. The civilization in question, now disoriented, loses itself in its own depths."

4) In a letter to Yanagiwa Seigan written in 1858, Sakuma Shôzan (1811–1864), whose slogan "Eastern morality, Western science" is well-known, remarks, "At present the learning of China and Japan is not sufficient; it must be supplemented and made complete by inclusion of the learning of the entire world"; see Hirakawa [1989: 442].

acceptance of these new ideas.

An example of sinocentric thinking in this period is found in the writings of Feng Guifen (1809–1874), the Suzhou scholar who first strongly encouraged the introduction of Western scientific knowledge into China. Feng simply could not accept the idea that the genius of China had been superseded by foreigners.[5] For Feng, China had simply to turn to its innate genius, and the problems would be resolved. Feng was by no means alone in this view, but tragically in this process China lost itself 'within its own depths', seeking analogies and counterparts within the Chinese cultural tradition. This tenacity of the grip of Chinese tradition and the past brings to mind a passage from the foreword to the well-known *Introduction à la Rennaissance* by Jules Michelet (1798–1874): "Nous avons évoqué l'histoire, et la voici partout; nous en sommes assiéges, étouffés, écrasés; nous marchons tout courbés sous ce bagage, nous ne respirons plus, n'inventons plus. Le passé tue l'avenir."[6] While lacking such a strong sense of cultural superiority, Japan had a correspondingly stronger sense of national identity and embarked upon a far-ranging programme of modern westernization so as to preserve its national independence.[7]

In China, we find fundamentally patterns of attempted change within the constraints of what was perceived as 'tradition'. Chinese scepticism to the concept of mechanical innovation could draw on a tradition that was centuries old. In a Chinese philosophical text dating from the third century B.C. we find the following remark, "if the benefit is not a hundred-fold greater one does not alter a law (*fa*), and if the improvement is not ten-fold greater, one does not change to a new device"[8]. Faced by the threat of Western naval might, China, in more ways than one, exemplified the following observation made by Thomas C. Smith, "Communities in danger do not necessarily seek safety in innovation; commonly

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5) In 1860 in his essay 'On the Manufacture of Foreign Weapons' he wrote, "What we have to learn from the barbarians is only the one thing, solid ships and effective guns ... Funds should be assigned to establish a shipyard and arsenal in each trading port ... *The intelligence and wisdom of the Chinese are necessarily superior to those of the various barbarians, only formerly we have not made use of them* (my italics) ... There ought to be some people of extraordinary intelligence who can have new ideas and improve on Western methods. At first they may learn and pattern after the foreigners; then they may compare and try to be their equal; and finally they may go ahead and surpass them"; see Teng Ssu-yü & John K. Fairbank [1979: 53–54].

6) "We have evoked history, and here it is everywhere. We are besieged by it, suffocated by it, crushed by it; we proceed bent double beneath this baggage. We can no longer breathe, we can no longer invent. The past kills the future."

7) Fukuzawa Yukichi (1835–1901) wrote in 1875: "Our goal is the preservation of national independence. There is no other way to do so except through the adoption of (Western) civilization. Japan must advance towards civilization for the sake of preserving (that) independence"; see *Fukuzawa Zenshu,* 10 vols. (Tôkyô: Jiji Shimpôsha, 1925–26), Vol. 4, pp. 255–256; translated in Hane [1982: 10].

they reaffirm tradition and cling to it more resolutely."[9] Japan, on the other hand, faced by a similar threat, was able within a short period of time to master foreign innovation and reach a new level of national security and prosperity.

2. TRADITIONAL SHIP-BUILDING TECHNOLOGY

To understand why China was culturally less prepared than Japan to come to grips with the advent of steamship technology, we must briefly review the levels of ship-building technology attained in the two nations, and thereafter the quite different reasons for the interruption in maritime activity in the two nations in the seventeenth century.

China had a magnificent maritime history. In pre-Renaissance times Chinese navigation and Chinese ship-building technology was indisputably superior to that of Europe. Testimony is provided as to the navigatory skills of Chinese and Japanese sailors by the fact that they travelled waters that were at least as dangerous as those of the Mediterranean or North Sea.[10] Chinese innovatory skills in maritime matters in early times may well be exemplified by the introduction of the use of the magnetic compass in navigation; it is known to have been used by Chinese navigators in the 1080s, a hundred years before its use in Europe [ZHU Yu 1989: 2/26]. While knowledge of the floating compass may have been transmitted to Japan from China first as late as the early fifteenth century, it was rapidly adopted, and the widespread use of the compass-card by the *Wakô* pirates in the early sixteenth century is well attested.[11]

Not only was traditional ship-building in China and Japan entirely different from that in Europe, but until the fifteenth century Chinese ocean-going vessels were larger and, with their transverse watertight bulkheads, more seaworthy than

8) See *Shangzi: geng fa,* 1/2a. The principle that a mechanical innovation could only be accepted and used if it was ten times more efficient than the existing device was repeated in the Han dynasty; see *Zhanguo ce,* 6/26a, which replaces the word 'law (*fa*)' found in the *Shangzi,* with 'customary practices (*su*)'. The ultimate source of this animosity to innovation is the Taoist classic the *Daode jing,* which has a passage which reads: "In a small country with few inhabits, even if there were devices requiring ten or one hundred times [less labour], the people would not use them"; see *Daode jing: du li,* B/20a.

9) See Thomas C. Smith, "Japan's Aristocratic Revolution" orig. printed in *Yale Review* 50: 3 (1961), reprinted in Smith [1988: 135].

10) We are reminded of the dangers of these waters by Thunberg's remarks that between 1642 and 1775 one out of five of the Dutch vessels bound for Japan foundered on their way in the Japanese waters; see Thunberg [1980: 11–13].

11) The first mention of the maritime compass in Japanese literature occurs in the *Senkô yôjutsu* (Essential Techniques of Navigation) of 1504; see Iida Yoshiro [1980: 45]. Knowledge of the Western development of the dry compass used in Japan in the sixteenth century was transmitted back to China and enjoyed great popularity among merchants there; see Needham [1962: 289].

European vessels for ocean journeys. Gigantic ocean-going vessels are well-represented in China's nautical history. Zhu Yu, whose father Zhu Fu had been Governor of Canton from 1099–1102, wrote in 1117 that according to government regulations large vessels carried several hundred men [ZHU Yu 1989: 2/26]. Sixty years later, the scholar-official Zhou Qufei noted that there were vessels with crews of several hundred men, which carried provisions for year-long voyages [ZHOU: 6/4a].

According to Ibn Batuta, during the twelfth to fourteenth centuries, these sizeable Chinese vessels were all constructed in Canton or Swatow. In the Ming dynasty, Canton remained the major centre for the construction of large merchantmen. In his *Haikou yi* (Treatise on Pirates), Wan Biao (1498–1556) writes of the remarkable vessel, built in Canton by the merchant Wang Zhi (d. 1559), which could carry two thousand men, and one hundred years later the gigantic two-masted ocean-going *mengchong* junks of Canton were praised by Qu Dajun (1630–1696).[12]

By way of comparison, Japanese vessels of the eleventh and twelfth centuries were notably smaller than Chinese vessels, with crews seldom being more than sixty or seventy men [YAMAKOSHI 1965 8: 25]. Japanese vessels continued to be considerably smaller than their mainland counterparts, and the majority of the Japanese vessels used in the Tally Trade during the fifteenth and sixteenth centuries were around six hundred to one thousand *koku*; according to the *Tsuchinoene nyû Min ki* of 1468, the largest was the *Izumi-maru* of 2500 *koku* [NIHON KÔGAKUKAI 1925: 19]. According to the late-sixteenth century officials Li Yangong (d. 1599) and Hao Jie (1530–1600), Japanese vessels, or at least those of the *Wakô* pirates, continued to be considerably smaller than Chinese,[13] and the largest Japanese vessel in pre-modern times, which was built in the early seventeenth century, was of the seven to eight hundred ton class and carried approximately four hundred men.[14]

Treadmill-driven paddle-wheel boats (*chechuan*) were already in use in China in the eighth century. In the 780s the ingenious Li Gao built a warship which was propelled by paddle-wheels, and moved through the waves as quickly as if it had sails.[15] In 1131, pirates under the command of Yang Yao captured several treadmill-driven paddle-wheel boats when they defeated a prefectural fleet. Thereafter they built several large treadmill-driven paddle-wheel boats, with which

12) See Qu [1985: 18/479]. For an explanation of the term *mengchong*, see Ye [1987: 79].

13) The largest had a crew of three hundred men, and furthermore there were other differences to Chinese shipbuilding, such as an absence of the use of iron spikes, or the use of pitch to caulk the timbers; see Li Yangong & Hao [1983: 1/28].

14) See Sugimoto & Swain [1989: 177]. Later, in the Tokugawa period, the largest ships built only had a tonnage of 1500 *koku*, see Yasuba [1978: 16].

15) See Liu [1975: 131/3640] and Ouyang [1975: 80/3582] which claims the vessel moved as quickly as a galloping horse.

they wreaked havoc on Lake Dongting. These vessels, which were armed with a pulley apparatus with which they could send large rocks crashing down onto smaller vessels, had two or three decks and could carry over a thousand men [XIONG: 13/165]. The prefectural officials immediately constructed several paddle-wheel boats, some driven by as many as thirteen treadmills, as well as a number of smaller craft driven by five treadmills, to combat Yang.[16] Yang Yao countered by building a massive flag-ship which was powered by twenty-two treadmills [ZHU Cishou 1988: 514]. The resourceful officials, in turn, responded by building even larger vessels.[17]

Treadmill-driven paddle-wheel boats continued to be used in naval campaigns until the end of the twelfth century, but thereafter their military use diminished [Lo 1960: 197f]. They remained common, however, as pleasure vessels on inland waterways in the thirteenth century.[18] Large treadmill-driven paddle-wheel boats seem to have become uncommon in the Ming dynasty,[19] but small paddle-wheel boats continued to be used widely as ferry-boats in Fujian and Guangdong until this century, although little technical development was made in their construction. I am unaware of any widespread use of treadmill-powered vessels in Japanese maritime transportation at any time.

3. THE DECLINE OF THE CHINESE MARITIME PRESENCE

For a variety of reasons the Chinese and Japanese maritime presence in Far Eastern waters suffered a great decline at the same time as European vessels sailed ever further eastwards. In China the decline was rooted in the long-standing aversion of the agrarian bureaucracy to maritime trade. China's maritime trade had been in the hand of merchants, not the state, and as such had been difficult to control. The decentralized overseas trade was incompatible with the continuing, we may almost say eternal, Chinese effort towards centralized control of society. While sea trade was an important if scarcely recognized component of the Chinese economy, by the Southern Song dynasty the steady outflow of gold, silver and copper cash from China was viewed with disfavour by scholar-officials. Repeated bans on foreign trade were promulgated, for example in 1182 and 1208 [TUOTUO 1977: 180/4396], but to no avail:

> After the establishment of the Southern Song dynasty, the junk masters who

16) See Li Xinchuan [86/1425] and Xu [1987: 50/17].

17) See Lu You [1/2a]. Yang Yao was eventually defeated by General Yue Fei (1104–1142) who skilfully used logs to jam the paddle-wheels, and attacked the large vessels with small boats; see Tuotuo [1977: 365/11384].

18) See Wu [12/6b]; translated in Needham [1970: 26].

19) When Fang Yizhi (1611–1671) briefly discusses these vessels, the three passages he quotes refer to the twelfth century and earlier, rather than his own times; see Fang [1978: 8/205].

> sailed the high seas every year were by no means few in number. The amounts of gold, silver, copper and iron which were lost when they were fleetingly carried away on ocean-going merchantmen were substantial, and the outflow of copper cash was enormous. Despite rigorous prohibitions, the trickery of the criminals became ever more devious. Merchants were greedy for profits and dispatched their wares; venal officials took bribes and allowed them to pass. In the final count, these despicable practices could not be (successfully) prohibited [TUOTUO 1977: 186/4566].

China's maritime expansion reached its peak in the early fifteenth century during the reign of the Yongle Emperor, with the famous voyages of Admiral Zheng He (1371–1433) which reached as far afield as the eastern coast of Africa.[20] Japanese vessels, however, appear never to have ventured further westwards than Rangoon in pre-modern times.

Chinese ocean-going maritime activity declined from the mid-fifteenth century onwards. One important reason was the capture of the Zhengtong Emperor in 1449 by the Oirat chieftain Esen, who thereafter beseiged the capital Peking.[21] From that time onwards, attention was primarily concentrated to securing the northern frontier, and the safety of this frontier virtually obsessed Chinese statesmen throughout the fifteenth and sixteenth centuries. An equally important, if rather less dramatic, reason was that in the early fifteenth century the sea routes which had been used in the Yuan dynasty for the transportation of the grain tribute from Southern China to the North were being replaced increasingly by use of the newly repaired Huitong canal system [HOSHI 1980: 2]. Debate continued into the late-fifteenth century as to the advisability of relying solely on in-land canals and attempts were made to continue using the sea route along the Shandong coast. However when in 1573 eight vessels of a fleet commissioned by the Director-general of Grain Transport Wang Zongmu (1523–1591) sank, he was forced to resign and further attempts were not made. Further discussion of the use of the sea-route was precluded by the objection raised by Zhang Juzheng (1525–1582), who argued that any continued use of the sea-route would lead to a decline in the use of the canal system, and as a result an impoverishment of the districts along the Grand Canal [HOSHI 1980: 12]. During the mid-sixteenth century, after the suspension of the Tally Trade in 1549, the incursions of the vessels of the *Wakô* pirates, originally manned by Japanese privateers but increasingly by Chinese crews, further served to decrease the interest in maritime enterprises within the Chinese central administration. Cumulatively, these points lead to an increasing landward orientation within the Chinese governing class during the fifteenth and sixteenth centuries, although not within the coastal merchant class, an orientation which had rigidified into 'traditional policy' by the early nineteenth century.[22] Governmental

20) At its greatest size, the Yongle fleet consisted of a central fleet of four hundred ships, a maritime transport fleet of three thousand ships, and two hundred and fifty treasure ships (*baochuan*); see Lo [1955: 493].

21) On the capture of the Zhengtong Emperor, see Wada [1959: 267f].

interest in promoting maritime innovation thus may be seen to have been rejected in China long before the Manchus made the political decision to close the country.

Additionally, the economic havoc which followed the entry of both China and Japan into global trade is an important contributory factor to understanding the early nineteenth-century disinterest in renewed Chinese participation. The late-sixteenth century had seen Chinese merchants once again engaged in trading activities in South-east Asia.[23] The entry of European vessels into East Asian trade changed the trade from a regional to a global concern. One important result was the rapid monetarization of the Chinese and Japanese economies during the period:

> After rapid economic growth in the late-sixteenth and early-seventeenth centuries, during the mid-seventeenth century both countries experienced severe economic problems that were at once interrelated and strikingly similar to those that were occurring in other parts of the world at about the same time [ATWELL 1986: 224].

China's difficulties stemmed in part from its great reliance upon bullion imports to prevent economic activity from contracting. When in the 1630s the amount of silver reaching China from South America and Japan radically dropped, the Ming government was unable to hinder the economic panic that broke out. The ensuing hoarding of silver, which destabilized the entire monetary system, left the Ming government sorely disabled in the face of domestic uprisings and Manchu invasion [ATWELL 1986: 229].

In Japan, the ban in 1635 on Japanese nationals from trading overseas meant a definite decrease in silver exports to China, and the expulsion of Portuguese traders from Nagasaki in 1639 severely affected trade. However, several important factors contributed to Japan's recovery in the late-seventeenth century, as compared with China's continuing domestic problems: an absence of costly campaigns against rebels, and of accompanying famines and epidemics, and the fact that although Japanese merchants prized Chinese goods and raw materials, alternative indigenous sources were available, and acceptable. While both nations more or less tightly closed their borders to overseas shipping for political reasons, in China there was additionally a distinct cultural aversion to the highseas among senior bureaucrats, a cultural aversion which did not exist in Japan. Global maritime trade in China had

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22) "To officials, the sea represented problems, not opportunities, and statecraft stopped, if not at the water's edge, centainly short of the high seas. *Paochia* and other registration and control techniques; forts, garrisons and coastal control squadron; and the management of government shipyards were among the foci of their interest. Chinese seafarers' solid knowledge of areas beyond the seas rarely found its way into discussions of statecraft"; see Wills [1981: 215].

23) In 1567 the absolute ban on Chinese ocean-going vessels was lifted, and by 1597 some one hundred and thirty-seven permits to trade overseas had been granted. However, direct official Sino-Japanese trade had remained in suspension, even though such trade took place illegally in South-east Asian ports.

been experienced as negative in the long run, and understandably there was little incentive to recommence voluntarily such trade.

4. THE FIRST INTRODUCTION OF STEAMSHIP TECHNOLOGY TO CHINA (1840–1842)

In China and Japan, steam-engines and steamships were known of many years before they were first viewed at close hand. The first mention in the Chinese language of the steamship appeared in Yang Bingnan's *Hailu* (Maritime Records), a work which is based upon conversations Yang had in 1820 with Xie Qinggao (1765–1821), at which Li Zhaolùo (1769–1841) was also present:

> America (*Yangligan guo*) lies to the west of England (*Yingjieli*)... at distance of about ten days travel. It is also a solitary island in the midst of the sea. Its territory is rather narrow. Originally it was under English rule, but now it is an independent kingdom. The customs are the same as those of England, and its vessels are those seen in Canton flying multi-coloured pennants. Its products are gold, silver, copper, iron, lead, tin, galvanized iron, glass, satin, foreign ginseng, snuff, *yalan* flour, foreign liquor, droguet cloth, camlet, and beiges. In this land, many steamers are used. Both inside and outside these vessels there are paddle-wheels. In the axles of these wheels there are boilers. When the fire is strong, it drives the wheels, which in turn rotate, stirring the water. Without making use of manpower, the vessels move by themselves. This machinery is ingenious, and no-one is allowed to catch sight of it. All the western countries have made imitations [YANG Bingnan: /50b].

Xie had worked as a sailor for fourteen years on Western ships, eventually retiring on account of failing eyesight, and had thereafter earned his living in Macao as an interpreter.[24] After studying other accounts of foreign lands, Li Zhaoluo reworked the information he had heard from Xie Qinggao, and gave a fundamentally similar description of the steamship, with one important addition. He found a cultural analogy for the steam-engine by comparing it to a sort of zoetrope, or toy wind-wheel (*zouma deng*),[25] which had been sold around the New Year festival in Suzhou since the fifteenth century, and was still popular in the 1820s.[26] What is important here is that, rather than accepting the steam-engine as a completely new innovation, Li Zhaoluo hearkened back to the past.

A passage in Wei Yuan's (1794–1856) *Haiguo tuzhi* (Illustrated Gazetteer of Maritime Countries) mentions that the first steamer to have visited China was seen in 1828, but it was in 1830 that the first vessel to which we can give a name, the East

24) See Yang Bingnan's preface to *Hailu*. On Xie Qinggao, see Hummel [1943: 449].

25) See *Haiguo jiwen,* quoted in Lü Shiqiang [1976: 3].

26) Mention of the *zouma deng* is found in Wang Ao's (1450–1524) *Gu Su zhi* (Local Gazeteer of Suzhou; preface 1506), and in the nineteenth century in Gu [1986: 1/24]. The zoetrope had, of course, an even longer history in China stretching back to the Tang dynasty and earlier; see Needham [1965: 565f].

India Company steamer *Forbes,* reached China.[27] In 1835 the *Jardine* attempted to steam up towards to Canton, but was repulsed. When finally three British wooden paddle-wheel steamers reached Canton in the summer of 1840, Governor-General Lin Zexu (1785–1850) was not unduly overawed and reported, "Recently three paddle-wheeled vessels reached here. They use the heat of flames to drive machines, which propel the vessels rather swiftly" [WENQING 1929: 11/18]. The following month Ulgungge (d. 1841), the Governor of Zhejiang, reported, "I have heard about the English pirate vessels... that on the sides of the ships there are paddle-wheels, which propel the vessels as swiftly as the wind, enabling the vessels to advance and retreat rapidly."[28] It is clear that little knowledge of the mechanics of the steam-engine had been acquired in the twenty years since Yang Bingnan recorded Xie Qinggao's account of steamers.[29] While there were officials in Canton who favoured the purchase of Western steamships,[30] voices were already raised at court advocating reliance upon traditional Chinese vessels.[31]

The initial Chinese reaction to the threat of the steamship was the construction of traditional paddle-wheel vessels at several different places along the coast. However, there does not appear to have been any attempt at concerting these efforts. For example, Gong Zhenlin, inspired by his sighting of a steamship off Ningbo, constructed a paddle-wheel vessel in Zhenhai in 1840, in which he replaced the steam-engine with man-power [WEI 1852: 86/2]. In Canton, the Salt-Examiner Changqing, Xu Xiangguang, and Pan Shicheng set to work to construct a large

27) See Wei [1852: 83/4]. The *Haiguo tuzhi* appeared in three editions: the first edition of fifty chapters appeared in 1844, the second of sixty chapters in 1849, and the third of one hundred chapters in 1852. Quotations in this essay are drawn from the 1852 edition.

28) See Wenqing [1929: 11/13]. On Ulgungge, see Wang [1987: 38/3008f]. One month later, Qishan (d. 1854), the Governor-General of Zhili, reported the eyewitness account of Company Commander Baihanzhang who had boarded a steamer, to the court: "(the steamer) has wind-mills (*fenglun*) on both sides of the vessel, both inside and outside. Within it there is a boiler, and above that there is a wind-catch. The fire is fanned by the wind, black smoke gushes forth, and the paddle-wheels agitate the water, turning by themselves. These vessels are able to move swiftly without making use of the wind or the tide, with the stream or against it"; see Wenqing [1929: 12/28–29].

29) Many Chinese entertained distorted ideas of how the steamships moved. Governor-General Qiying (d. 1858) felt able to dispell the rumour that the steamships were in fact moved by man-power or by the use of oxen, explaining that that they were,"propelled by a mechanism like that found in clocks and watches, and which cunningly derived power from water and fire"; see Wenqing [1929: 59/48]; translated in Lo [1960: 194].

30) Ishan (d. 1878), the military commander in Canton, following the advice of officials who had boarded an American warship, suggested the purchase of a triple-decked warship with seventy cannons to combat foreigners; see Wenqing [1929: 61/39].

31) In a memorial on tactics to defeat them, Senior Metropolitan Censor Zhu Chenglie cited the case of the use of small ramming vessels by the twelfth-century general Yue Fei when he defeated the paddle-wheeled pirate ships on the Dongting Lake; see Wenqing [1929: 26/2].

paddle-wheel vessel, which could carry more than one hundred men.[32] A report on the activities of Xu and Pan submitted on 8 November 1841 by Ishan (d. 1878), the military commander in Canton, met with imperial favour.[33] The emperor concurred that the construction of ships and cannons was important and ordered that modern western-style ships, rather than traditional ships should be built.[34] However, this positive imperial command was soon rescinded. When Qiying (d. 1858), the Governor-General of Jiangsu and Jiangxi, criticized the boats built by Pan Shicheng as not being as seaworthy as traditional Fujianese ships and those built by Xu Xiangguang as being unusable on the waterways of Jiangsu [Wenqing 1929: 64/29], the emperor agreed with Qiying's suggestion to continuing to build traditional vessels, under the supervision of Li Tingyu, the Provincial Military Commander of Zhejiang.

At least four more separate attempts at steam-engine construction without foreign assistance, and with only rudimentary diagrams to work from, took place in the early 1840s. Pan Shirong, with the assistance of a European engineer, completed his construction of the first full-scale Chinese steam paddle-boat in 1842 in Canton, but did not achieve any significant mechanical success. In his report, written in December 1842, Governor-General Qigong (1777–1844) remarked that the engine was not specially ingenious as Chinese craftsmen knew nothing of western machinery, and that foreign assistance should be sought [Wenqing 1929: 64/16]. Qigong further advised that in addition to attempting to imitate western technology, steamships should be purchased. The imperial reply was exceedingly negative, stating that as the ships that had already been built were not being used, there was no need to employ foreign engineers, and no funding would be allocated to purchase foreign ships [Wenqing 1929: 64/17].

Independently of Pan Shirong's attempts, two colleagues of Gong Zhenlin, called Ding Gongchen (1800–1875) and Zheng Fuguang (1780–ca. 1850), began to research upon steam engines and paddle-steamer construction in Zhejiang in 1841. Zheng noted:

> I was unable to understand anything clearly from the previously transmitted drawings and descriptions of steamships, and when later I saw a model vessel, which was only five or six feet long, the machinery was all within the hull, and

32) See Wei [1852: 84/23]. While neither this vessel nor that constructed by Gong Zhenlin was completed in time to take part in engagements when the Chinese fleet encountered the British fleet at the Battle of Wusong in 1842, the Chinese fleet did include five treadmill-powered paddle-wheel junks, all of which were captured or destroyed in the fighting.

33) Ishan's report, to which he had appended drawings and descriptions, stated that Pan Shicheng had built a copper-bottomed wooden ship of western construction, and was presently constructing two new larger western-style ships; see Wenqing [1929: 61/38].

34) The emperor further noted that the appended drawings had been copied and sent to the Governors of Jiangsu, Fujian and Zhejiang; see Wenqing [1929: 61/41].

thus invisible. It was first when I saw a diagram of the interior of the machinery that Ding Shoucun possessed that I could match it together with the earlier drawings and understand how a steam-engine works.[35]

Elsewhere, the Shanghai official Huang Shiquan tells us of the solitary experimentation of Dong Zishan, a Vice-Prefect of Taizhou on the Zhejiang coast, which lead to the construction of a steam-launch for estuary use:

> Long ago Zu Chongzhi (429–500) built the thousand *li* boat. It uniquely made use of a rotating device for its propulsion, and did not need poles or oars; it could rush forward by itself. Western paddle-steamers fundamentally use the same method. The vessels solely use the force of steam, and thus if they do not have their coal-fires burning for any length of time, they can scarcely move an inch. Vice-Prefect Dong Zishan from Taizhou was highly knowledgeable about western studies, and said that a different method ought to be devised, so that one could dispense with coal and only use steam. Westerners all smiled condescendingly at this suggestion. Dong pondered deeply, and after great efforts spanning several years, he built a launch which he named the *Hunchun.* Shortly afterwards, it ran aground on Caishi Rock and, striking an underwater reef, it sank. Thereafter Dong changed the construction of the vessel, and built a steam-launch, which he named the *Hunchu,* at the Gaochang Temple shipyard. It was six *zhang* in length, and had a draft of five *chi*; it could travel at a speed of twenty *li* an hour when travelling on a river. It was completely made of wood, with the result that when it met with the buffeting of sea waves, it was difficult to control.[36]

Huang Shiquan continues to remark that while James Watt and many others worked on the invention of the steam-engine at a cost of great sums of money, Dong had made the discovery working alone, an interesting reminder of the Chinese inventor's solitary struggle to reinvent foreign innovations. Furthermore, at this time a Chinese with experience of foreign engineering appeared in Zhejiang; the Cantonese He Ligui had spent twenty years outside China working in foreign shipyards, and knew how to construct steamships.[37] However, in keeping with the general weakening interest in research in western technology, his skills were not really fully exploited.[38] As in Canton, experimental steamship construction was

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35) See Wei [1852: 85/1]. On Ding Shoucun, who successfully experimented with various new forms of landmines, see Zhao [1977: 505/13928]. The first Chinese drawings of the steamship and steam locomotive occur in Ding Gongchen's *Yanbao tushu* (Illustrated Treatise on Gunnery) of 1841, and the first detailed drawings of steam-engines are found in Zheng Fuguang's *Jingjing lingchi* (Bragging to Myself in the Mirror) of 1847; see Bai & Yang [1984: 285]. The illustrations were subsequently incorporated into the expanded 100-chapter edition of Wei Yuan's (1794–1856) *Haiguo tuzhi* (Illustrated Gazetteer of Maritime Countries). The title *Jingjing lingchi* refers to a southern Chinese expression (*lingchifu*) found in a passage by Yan Zhitui (ca. 529–591); see Yan [A/37b].

36) See *Songnan mengying lu* (Record of Reveries at Songnan),/10a, included in Wang Xiqi's *Xiaofanghu zhai yudi congchao,* volume 9, page 96a.

37) See Wenqing [1929: 59/24] and *Xuan zong shilu* [1988: 386/7b].

discontinued in Zhejiang.

In his analysis of the reasons for the discontinuation of Chinese steamship research in the 1840s, Lü Shiqiang points out that it cannot have been purely economic considerations which were the stumbling block. The cost of the construction of a fleet of twenty western steamships would have been about one million taels of silver, while the military expenditure in the First Opium War amounted to seventy million taels [LÜ 1976: 28]. Even the local government of Canton could have afforded the construction of several steamships since, according to Yang Fang (1770–1846) who was assistant commander to Ishan, military funds in 1841 in that city amounted to nearly four million taels [WENQING 1929: 26/37]. Secondly, it was not through a lack of willing engineers, as the experiments made by Ding Gongchen and Zheng Fuguang demonstrate. Thirdly, the several references to the experienced engineer He Ligui in official documents of 1842 and 1843 show that he was known to the regional and central government. If he had been employed along with Ding and Zheng, successful steamship construction would certainly have been realizable. However, the coming of peace undermined the interest of regional officials to engage in innovative technology, and it was first in the 1860s that research on the steam-engine was seriously taken up again in China. In the interim period Japanese engineers advanced from their first experimental constructions to full production capability. The disinterest on behalf of the Chinese bureaucracy tends to confirm the contention that technological borrowing is 'the function of the balance of social forces which favor or inhibit change and innovation and which limit or facilitate individual action' [FAIRBANK 1955: 195]. In China, in a way unlike Japan, social forces were inimical to change, and individual action was limited and discouraged.

News of the Opium War, including information concerning the role played by steamships, reached Japan promptly [OBA 1980: 34]. This information was added to the knowledge gained on modern warships through translations of Dutch works, such as Motoki Shôzaemon's (1767–1822) *Gunkan zukai* (Illustrated Explanation of Warships) and the translation of Calten's work on gunnery by Sugita Seikei (1817–1859) and Udagawa Yôan (1798–1846) in 1843 under the title *Kaijô hôjutsu zensho* (A Complete Text on Maritime Gunnery).[39] The major work to introduce steamships to Japan was Mitsukuri Genpo's (1799–1863) translation in 1849 of Gideon Jan Verdam's (1802–1866) *Gronden der toegepaste werktuigkunst* ... (1834), under the title *Suijôsen setsuryaku* (An Abbreviated Treatise on Steamships).[40] While popular in Japan, Wei Yuan's *Haiguo tuzhi* was not without its contemporary Japanese critics. Takasugi Shinsaku (1838–1867) remarked in his

38) According to various memorials, He Ligui was retained in Zhejiang supervising the construction of warships from January to September 1843, but thereafter he is not mentioned again; see *Xuan zong shilu* [1988: 389/7b, 394/18a, 395/31a].

39) See Arima [1964: 127]. Udagawa Yôan is of course best known for his contribution in the development of Linnean botany in Japan; see Bowers [1970: 100].

diary that even though the Chinese possessed Wei Yuan's book, they had failed to plan a defense capable of protecting the country from within and without [HAROOTUNIAN 1980: 35]. In fact, the country lacked any understanding of western armaments. Engagements had been fought with the foreigners and lost. Owing to obstinacy and idleness, "they did not know how to absorb the new foreign studies" [HAROOTUNIAN 1980: 35].

Similarly Sakuma Shôzan (1811–1864), who read Wei Yuan's work after he had submitted a memorial on a coastal defence to his *daimyô,* wrote "Wei and I were born in different places and did not even know each other's name. Is it not singular that we both wrote lamenting the times during the same year, and that our views were in accord without our having met? We really must be called comrades from separate lands" [JANSEN 1980: 341]. Yet, while Sakuma may have admired and agreed with Wei's intentions, he had less positive to say for Wei Yuan's discussion of armaments:

> It is for the most part inacurate and unfounded. It is like the doings of a child at play. No one can learn the essentials of a subject without engaging personally in the study of it [JANSEN 1980: 341].

In Japan, unremitting perseverance in the practical study and application of western technology laid the foundation of an engineering capacity far superior to that found in China.

5. THE PRELUDE TO THE INTRODUCTION OF STEAMSHIP TECHNOLOGY TO JAPAN: REVERBERATORY FURNACES

In Japan, the origins of the steamship industry were closely related to the modernization of the iron industry. This, in turn, was founded on the efforts of former students of the academies where western medicine was taught, primarily the *Nisshôdô* and *Shôsendô* Academies, despite the ban on all western learning including medicine promulgated in 1849; all western learning other than medicine had already been banned in 1840. The modern iron industry may be said to have begun in 1850 when the construction of the first successful reverberatory furnace began at Saga. The task was carried out under the supervision of Sugitani Yôsuke (1820–1866), using the translation which he had made together with Itô Genboku (1800–1871), the founder of the *Shôsendô* Academy in 1834, of Ulrich Huguenin's *Het Gietwezen in's Rijks Ijzer-Geschutgieterij, Te Zuik* (1826), to which he gave the

40) The earliest edition of this work held in major libraries is C. H. Schmidt's translation into the German with the title *Grundsätze der angewandten werkzeugswissenschaft und mechanik*...(1834); the earliest Dutch edition listed in Brinkmann's catalogue is 1835. While Wei Yuan's *Haiguo tuzhi* spread knowledge of the steam-engine in China earlier than 1849, it was first in 1851 that three copies of the book reached Japan. However, they were rapidly seized by *bakufu* police, and it was not until 1854 that Japanese translations became available; see Ôba [1980: 244f].

title *Tekkô zensho*.[41] After the completion of the furnace in 1852, Sugitani composed the *Hanshô no yurai* on the course of the work [IIDA Ken'ichi 1971: 71].

When Shimazu Nariakira (1809–1858) became *daimyô* in Satsuma in 1851 he established a laboratory (*Seirenjô*) where experiments based on Dutch works on problems such as the plating of metals, the bleaching of silk and cotton cloth, and the manufacture of acids, alcohol and glass were carried out [SMITH 1948: 134]. In 1852 a similar laboratory was established Saga, and it was there that the first iron cannon was successfully cast in 1853; it was bored using a water-wheel that had been installed the previous year [MINAMI 1982 1: 40]. Satsuma, which had already built a model reverberatory furnace in 1852, built a full-scale furnace in 1853 and began casting iron cannon. These were bored out using a device, built according to sketches in a Dutch work, which was powered by a water-wheel [SMITH 1948: 139]. In 1854, a blast furnace was built which completed the development of Satsuma's iron industry.

The successes in Saga and Satsuma lead to the building of reverberatory furnaces in Mito, Nirayama, and elsewhere.[42] In 1853 Yada Hyôsuke was ordered by Egawa Tan'an (1801–1855) to travel from Nirayama to Saga. After studying the technical developments achieved there, Yada returned to Nirayama. Initial efforts at furnace construction were seriously damaged by the earthquake of 1855. Aided by Sugitani Yôsuke and Tashirô Magosaburô who specially came from Saga to participate in the repair of the furnace, Yada finally succeeded in completing a reverberatory furnace there in 1857 [TOKYO KAGAKU HAKUBUTSUKAN 1980: 224]. Furthermore, Egawa Tan'an established the *Nirayama ransho honyakuhô* for the translation of foreign literature at Nirayama. One of the translators Yatabe Kyôun, a former pupil of Tsuboi Shindô's (1795–1848) *Nisshûdô* Academy, was able to take considerable advantage of the information network which had come into existence on account of the work on reverberatory furnaces, when he made a translation to which he gave the title *Seidô oyobi chûtetsu wo yôkai suru hansharo wo shirusu* (A Record of the Reverberatory Furnace for Smelting Copper and Iron).

Yatabe's translation closely resembled a new translation of Huguenin's work made by Tezuka Ritsuzo (d. 1876) in 1850, which he titled *Seiyô tekken chûzo hen*. This new translation had been achieved by Tezuka with the assistance of Takeshita Seiemon from Satsuma, Kumata Kamon from Miharu, and Ôshima Takatô (1826–1901) from Nanbu, who had travelled to Nagasaki in 1846 to study under Tezuka.[43] Here, we have a clear example of the importance and value of the

41) An English translation of the title of Huguenin's work is *Smelting Methods in the State Gun Manufacturing Plant at Luik*. Sugitani had found Huguenin's book in Edo in 1847 when he went there to study at the *Shosendo*; see Yamazaki [1978: 138].

42) See Yamazaki [1978: 138]. For a list of the dates of construction of reveberatory fumaces in various *han*, and an illustration of four furnaces, see Tokyo Kagaku Hakubutsukan [1980: 224f].

43) Huguenin's book was translated a third time by Kanamori Kinken in 1856 with the title *Tekko Chukan*; see Arima [1964: 129].

burgeoning information network. In 1855, in accord with a policy drawn up by Tokugawa Nariakira and Fujita Tôko, the three assistant translators jointly constructed a full-scale furnace in 1855 in Mito [IIDA Ken'ichi 1971: 73]; a water-wheel driven barrel-boring apparatus was also installed [MINAMI 1982: 41]. In 1858, a blast furnace was built which completed the development of Mito's iron industry.

In passing, we may note the Japanese use of water-wheels in the modernization of their industry is of some interest. Water-wheels had been used in traditional Japanese industry, for example in rice-cleaning, in flour-milling, in the grinding of oil-seeds, and in silk yarn production.[44] The expanded use in the boring of cannons, in the textile industries and in iron ore mining is interesting as it to a certain extent parallels developments in the west. For example, in the first half of the nineteenth century American manufacturing relied heavily on water-power, and it was first in 1870 that steam engines began to outnumber waterwheels and turbines [ATACK 1979: 412].

6. THE INTRODUCTION OF STEAMSHIP TECHNOLOGY TO JAPAN (1851–1866)

The early stages of the development of the iron industry were achieved in Satsuma, Saga and Mito, using translations from Dutch manuals but without foreign assistance. This was also the case with ship-building, where the efforts in Satsuma and Mito in steamer construction were based solely upon practical study of applied Western skills [SMITH 1948: 412], although Saga did employ one Dutch engineer. Furthermore, the construction of reverberatory furnaces in the various *han* resulted in the development of the earlier private academies of Dutch medical learning into a nation-wide infrastructure of empirical knowledge which was of significant importance in experimental steamship construction. Learned academies, of course, existed in China and it is possible that had the central objective of mid-Qing scholars not been the reconstruction of antiquity they might have had the same role as Tokugawan academies. Indeed in the opinion of Benjamin Elman, "had the natural sciences been recognized and developed as important individual disciplines in eighteenth-century China, the organizational mechanisms for their growth and development were readily available" [ELMAN 1984: 137]. However, such was not the case, and solitary Chinese engineers, lacking literature and contact with colleagues, struggled in a way quite unlike their Japanese counterparts.

Tanaka Hisashige (1799–1881), a townsman rather than *samurai* — whose inventive genius lead him in 1875 to found the Tanaka Seisakusho, the forerunner of the Toshiba Group — played a crucial role in the introduction of steamship

44) For an excellent introduction to the water-wheels used in traditional Japanese industry, see Demizu [1987: 44f].

technology to Japan. He was just the sort of man whom Feng Guifen envisaged in his essay on the manufacture of foreign weapons, mentioned above. From an early age Tanaka was interested in mechanical innovations, and when he was only fourteen years old he built a bamboo water-wheel [MIYOSHI 1983: 54]. In the 1820s a vogue for mechanical toys (*karakuri*) swept through Japan, and Tanaka was swept along with it, becoming a brilliant inventor. In 1834 he moved to Osaka where he invented a portable lamp, and three years later he moved to Fushimi where he invented a so-called perpetual lamp. In 1850 he moved to Kyôto, where he opened the renowned *Karakuridô,* and completed his famous perpetual clock. In recognition of his skill, the Imperial Regent Takatsukasa Masamichi awarded him the title of Leading Craftsman. While residing in Kyôto, Tanaka became a student with Hirosei Genkyô (b. 1820) at the *Kyûridô* Academy, which had been founded by Koishi Genshun in 1801. The two men became friends, and eventually Hirosei married Tanaka's sister Ineko. Hirosei himself had been a student at the *Nisshudô* Academy, along with Mitsukuri Genpo, Sugita Seikyô, and Ogata Kôan, who founded the famous *Tekiteki* Academy in Osaka.

Tanaka, who had previously used springs and water power in his mechanical toys, now began to study the principles of the steam-engine, and built several steam-engine driven mechanical toys. More importantly for our considerations, in 1852 he built two model steamers, one with external paddle-wheels and the other with screws, which he tested upon a pond in his garden. These models, which were built of wood, had brass machinery which was even equipped with safety valves. Nevertheless Tanaka's skills might have remained within the sphere of mechanical toys if it had not been for Sano Tsunetami.

In 1846, on the order of the Saga *daimyô* Nabeshima Naomasa, Sano became a pupil of Hirosei. Later he travelled to Edo where he became the chief of the *Shôsendô* Academy. On his return from Edo to Saga in 1852, Sano visited Hirosei Genkyô. At this time Saga, which had responsibility for guarding the coastline in the Nagasaki area, was studying Dutch technology for cannon production. Sano was aware that the Satsuma *daimyô* Shimazu Nariakira had already started to experiment with the construction of model steam-engines at his residence in Edo in 1851, using Mitsukuri Genpo's (1799–1863) *Suijôsen setsuryaku* (An Abbreviated Treatise on Steamships).[45] Sano felt strongly that Saga should also begin constructing steamships and recommended his fellow students under Hirosei to serve in Saga. Among those who responded to his appeal were Tanaka and his adopted son Tanaka Yoshiuemon, Fukuya Keikichi from Kyôto and Baba Isokichi from Saga. Sano was appointed head of a new laboratory in the winter of 1852. One of the main topics of research carried out at this laboratory concerned the construction of steam-engine boilers, but it would be first ten years later that

45) See Nakanishi [1982 1: 96]. Mitsukuri Genpo later become one of the main teachers, along with Sugita Seikei, in the academy for western studies which the *Bakufu* established in 1855, and which was renamed the *Bansho chôso* in 1857.

Tanaka would achieve full success. Tanaka was initially hampered by a lack of western literature; as he noted in 1853 in his *Jôkijû ryakuki* (Brief Notes on Steam-engines):

> I have no explanations of (the construction of) Western steam-engines. I thought that I could build such machines with my many years of foolish experience. If I can obtain Western books on steam-engines, and peruse them thoroughly, I can surely make better machines than Western craftsmen.

In 1854, Saga established a shipyard in Mietsu, and the following year Sano and Tanaka built a model steamboat and a model locomotive, as well as a model telegraph, at the laboratory. In 1863 construction of an external wooden paddle-wheel steamer was begun, and in 1865 the *Ryôfu-maru,* as it was known, was completed. This vessel, which had an engine that produced ten horse-power, was the first domestically constructed Japanese steamship. At the time of its completion, the work-leaders were Tanaka and his son Yoshiuemon, Fukuya and Baba, who all thus had been involved in the entire project from inception to completion.

Saga was not the only centre of innovation. Shimazu Nariakira established a shipyard, called the *Shûseikan,* in Satsuma where as many as 1,200 craftsmen were employed [SUGIMOTO Isao 1967: 343]. Encouraged by the *Bakufu,* an advanced sailing vessel, the *Shôhei-maru,* was built there in 1853. However, the above-mentioned attempt in 1851 by Shimazu Nariakira to build a steam-engine had not been successful, and it was first in 1855 that Higo Shichizaemon and Umeda Ichizô were successful. The engine was mounted on a small launch, the *Unkô-maru,* and worked satisfactorily during trials [NAKANISHI 1982 1: 96]. According to Kattendijke (1816–1866) who saw the steam-boat in 1857, the engine which had been built according to Verdam's diagrams, had several faults as a result of which it could only produce two or three horse-power, rather than the twelve horse power it should have produced.[46] In Mito, progress was a little slower than Saga and Satsuma, with the first Western-style ship being completed in 1856. However the efforts at Mito lead to the opening of the Ishikawajima Shipyard where the first domestically produced Japanese steam warship, achieved without any foreign assistance, was constructed. On the order of the *Bakufu,* the ship was designed by Ono Tomogorô and an engine planned by Hida Hamagorô (1830–1899), and work begun in 1862 [ARIMA 1964: 136]. With the completion in 1866 of this 136-ton ship, the *Chiyodagata-maru,* we may consider that steamship technology had been

46) See Kattendijke's diary, quoted in Nakanishi [1982 1: 96]. I believe that the following notice quoted from the *Nautical Magazine* of November, 1859, refers to this steamboat: "The greatest curiosity at Nagasaki is a small steamer built entirely, the native engineer says, from drawings he met with in an old Dutch work. Dutch engineers are correcting some slight defects of the engine"; see Smith [1948: 143]. In Satsuma, the progressive trend which lead which lead to the *Unko-maru* was curtailed in 1856 by the establishment by the *Bakufu* of the Nagasaki Naval Training School.

successfully introduced to Japan.

The steamship's rapid integration into Japanese culture is evident. The steamship appears in many traditional *kanshi.* Perhaps the first mention was by Ônuma Chinzan (1818–1891) who, in a poem written in 1869, somewhat iconoclastically allowed a reference to an early mediaeval Chinese tale to be followed by mention of a steamship:

> A yellow road hangs over the tops of the waves;
> To the south of India is the Southern Pole of the Heavens.
> Riding a raft along the Milky Way is no extraordinary thing here,
> As our steamship churns up into the solar orbit.[47)]

In 1871 Kanagaki Rôbun (1829–1894) began his preface to his comic novel *Seiyôdôchû hizakurige* (On Shank's Mare along the Highway to the West), a parody of Jippensha Ikku's (1765–1831) humourous narrative *Tokaidôchû hizakurige,* with the following words:

> Let us suppose that we compare a fictional tale writer to a steamship, then the various plots of his story are like the ship's masts and funnels. When the machinery is lubricated with illustrations, the writer's rushing brush becomes like the engine's paddle-wheels. Like the smoke from the funnels, true tales and fictional stories are transformed, and the ship's (*battêra*) devices are brought to their completion...[48)]

The steamer had become sufficiently commonplace by this time to be a subject for parody. It is interesting to note that almost ten years previously, in 1862, Kanagaki had composed a short essay on a Russian steamer that had visited Japan. This essay had been provided with an illustration in the form of a woodblock print by Yoshitora, which while revealing that Yoshitora had probably never seen a steamer, undoubtedly spread knowledge of the new sort of vessels with their 'clouds of smoke'.[49)] Even Buddhist monks found the steamship an acceptable reference in otherwise traditional religious verse. The monk Mokurai (1838–1911) concludes a poem written on his visit to Buddhist sites in India in 1873 with the following four lines:

> The length of my life is limited, but my gratitude to the Buddha is limitless;
> Visiting the sites connected with his superior being, I forgot my tribulations.

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47) See the second in the series of poems titled *Seiyo kiko daishi,* in *Meiji kanshi bunshu,* p. 8 (*Meiji bungaku zenshu* [1989: vol. 62]). The tale of riding a raft along the Milky Way is first found in Zhang Hua's (232–300) *Bowu zhi,* 3/3a; it is translated and discussed in Greatrex [1987: 95].

48) See the preface to *Seiyô dôchu hizakurige* in *Meiji kaikaki bungakushu,* Part 1, p. 3 (*Meiji bungaku zenshû,* [1989: vol. 1]). The expression *battera* is also found, for example, in chapter four of Seino Ryôeki's *Ushiro monogatari*; see *Seino Ryoeki shu,* p. 85 (*Meiji bungaku zenshu* [1989: vol. 15]).

49) An illustration of this *hanga* is found, for example, in Catalogue #29 of Harashobô (1989), p. 37.

The churning of the steamship destroys my wayfarer's anxious dreams;
Over the outskirts of Calcutta, the evening sun sets.[50]

7. THE SECOND INTRODUCTION OF STEAM TECHNOLOGY TO CHINA (1862–1865)

Before considering the second introduction of steam technology to China, it is appropriate to review the state of the Chinese iron industry in the 1850s in the light of the importance of the modernization of the Japanese iron industry. The traditional Chinese iron industry had reached a considerable degree of pre-industrial sophistication by the beginning of the nineteenth century. However the post-Opium War period saw a rapid disintegration of the domestic productive capacity. The reason was purely economic; throughout the country, cheap western iron more or less completely replaced the domestic product.[51] According to Zhang Zhitong (1837–1909), Hunanese iron, which had long enjoyed an exceedingly high reputation and had been used throughout the Zhejiang coastal region up to 1850, was ousted by foreign iron. Li Hongzhang (1823–1901) gave a similar view of the situation in South China in the 1850s, continuing to remark that the quality of the dearer domestic iron decreased to such a point that 90% of it was unusable [ZHU Cishou 1989: 133]. One specific example of this phenomenon highlights the issue. In the 1850s there had been forty workshops producing iron in Xiangtan to the south of Changsha, with sales throughout the country. In 1909, only six workshops remained. In other words, the crucial period of the introduction of steamship technology to China saw a dramatic deterioration in the domestic iron industry. Here I may also mention that while coal-mining was by no means developed in either Japan or China at the beginning of the nineteenth century, the positive developments with regard to production capacity, if not the health of the conscripted coal miners, at the Takashima Coal Mine in Saga were not repeated in China. In China prior to 1850 demand for coal was limited and costs of production and transportation were high [BROWN AND WRIGHT 1981: 61]. Imported coal dominated the market, and the domestic coal mining industry developed extremely slowly.

The man who comes nearest to playing the role in China of that played by Tanaka Hisashige in Japan is Xu Shou (1818–1884). Xu was born in Wuxi in Jiangsu of relatively humble origins, and was orphaned when still a small child. He was greatly interested in scientific matters, and as a result of the upheavals of the Taiping Uprising, he abandoned his studies towards an official career. Hua Hengfang (1833–1902), who was to become Xu's lifelong friend, was the son of a

50) See *Indo kankuwai,* in Inoguchi [1972: 613].

51) According to a customs report written in 1868, foreign iron had completely replaced the dearer domestic product in the regions of Ningbo and Shantou; see Zhu Cishou [1989: 132].

minor Jiangsu official. At the age of thirteen he was given a copy of a Ming dynasty work on practical calculation using the abacus, Cheng Dawei's (ca. 1520 - ca. 1600) *Suanfa tongzong,* which he greatly enjoyed. His father then bought him other mathematical treatises such as the *Jiuzhang suanshu,* and Hua's career as a mathematician was begun. Some years later Hua obtained the writings of Song and Yuan dynasty mathematicians such as Qin Jiushao and Li Zhi (1192–1279), and was so competent that he was able to add commentaries which elucidated points that the early-nineteenth century mathematician Song Jingchang had been unable to grasp correctly [Min 1987: 43/1516]. Xu and Hua could only understand a small part of what they read in the western scientific literature available in China. Additionally they had difficulty in obtaining equipment. For example, when they wished to experiment with the refraction of light, they were unable to purchase a prism, and were forced to grind one by hand from a piece of crystal [Zhao 1977: 505/13929]. However Xu and Hua continued their studies and gradually attained success. In the late 1850s, while helping Alexander Wylie in Shanghai, Xu saw a copy of Benjamin Hobson's (1816–1873) concise encyclopedia titled *Bowu xinpian,* in which there were twelve sections concerning the steam-engine.[52] This work was his primary source of knowledge on the topic.

On 26 December 1861 Zeng Guofan (1811–1872) invited Xu, Hua and another four men to come to Anqing to experiment with the construction of steam-engines. The working group which assembled there additionally consisted of Xu's son Xu Jianyin (1845–1901), who was later to visit Europe in the 1870s, Wu Jialian and Gong Yuntang. In July 1862 they completed a prototype steam-engine and demonstrated it to Zeng.[53] Thereafter they continued to build a wooden steam-launch. In their work, Hua was chiefly responsible for the calculations and measurements, and Xu for the construction of machinery; no use was made of the help of western engineers. The engine of their first launch, completed in November 1863, was not sufficiently strong and the boat stopped after only moving a few hundred meters. On 28 January 1864, Zeng was invited to board a new steam-launch, and then taken on a trip on the river, travelling at a speed of about 12 *li* per hour. While he was cheered by the experience, Zeng was nevertheless disappointed at the slow speed of the launch and its relative lack of engineering sophistication.[54]

The same year Zuo Zongtang (1812–1885) also attempted to construct a steamer using Chinese craftsmen and methods, but its trial run on the Western Lake at Hangzhou was far from satisfactory, and the project was discontinued [Hsü

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52) This short compendium of western scientific and technical knowledge was assembled by Hobson, and published under his Chinese pen-name He Xin by the Mohai shuguan publishing company in Shanghai in 1855,

53) For a translation of Zeng's impression of the steam-engine, written in his diary for 30 July 1862, see Joseph Needham [1965: 390].

54) See Zeng Guofan's diary quoted in Zhu Dongan [1985: 323].

1978: 345]. Zuo Zongtang was a staunch believer in the importance of steamers, but distrusted railways and considered that other foreign devices were unimportant; the possession of steamers alone would preserve Chinese national sovereignty. His lack of comprehension of the significance of other modern inventions is demonstrated by the fact that when a French engineer showed him a telegraph, Zuo purchased it as a curiosity, and thereafter stored it unused in the Fuzhou prefectural treasury [WRIGHT 1957: 266].

In the late summer of 1865, Xu and Hua completed the *Huanghu,* a 25-ton wooden-hulled steamer, which could travel at a speed of 20 *li* per hour.[55] The machinery, excluding the axles, boiler, and funnel, had been built at the Anqing shipyard, at a total cost of eight thousand taels of silver. Chinese engineers had demonstrated that they could build a steamer without western assistance. However, while perhaps better than the *Unkô-maru,* the technical achievement of the *Huanghu* fell short of the *Ryôfu-maru,* and was quite over-shadowed by the *Chiyodagata-maru.*

In 1868 the first Chinese steamer, the *Tianqi,* a 600-ton side-wheeler was launched. Part of the engine had been built at the Arsenal, while the remainder had been purchased second-hand from abroad [ZHU Cishou 1989: 255]. Over the next five years five screw-driven ships, of which the *Hai'an* and *Yuyuan* displaced 2,800 tons, as well as three small armour-plated vessels with twin propellers were built at the Jiangnan Arsenal, where Xu, his son and Hua were all employed. For all but two of the ships, the engines and boilers were constructed by Chinese engineers, which bears witness to their technical ability. However, it is not fully correct to infer that Chinese engineering had caught up with Japanese levels, since these vessels proved to be too slow and to consume too much coal, and were at least twice as costly as comparable foreign vessels produced in Britain.[56] The tragic result was that the entire steamship ship-building programme at the Jiangnan Arsenal was discontinued in 1875, and only repair work was undertaken thereafter.[57] As Liang Hongzhang wrote at this time:

> Although each ship was produced by us here at the Arsenal, there was no other means than to buy the vast majority of the materials from abroad, and employ foreign engineers in the construction work. It was more or less the same as buying the ships from abroad.[58]

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55) The vessel was described in detail in the August 31 copy of the *Zilin xibao* newspaper.

56) The high costs for construction at the Arsenal stemmed from the fact that nearly all material was imported and that the personnel cost was high. The personnel costs continued to rise because of increasing number of foreigners employed, and also the increasing size of the Chinese administration; see Kuo & Liu [1980: 522–524].

57) Even the Fuzhou Shipyard, founded by Zuo Zongtong in 1866, was plagued with severe financial difficulties in obtaining allocated funds, and the ships it produced in the 1870s, like the vessels constructed at the Jiangnan Arsenal, with their wooden hulls and single-beam engines were slow and already obsolescent by contemporary European standards, as well as being costly to produce and operate; See Kuo & Liu [1980: 524].

Despite the remarkable efforts of many Chinese engineers, steamship technology could gain neither the institutional support it required nor the intellectual attention it demanded in the 1870s. The cultural imperative during the Tongzhi Restoration of 1862–1874, experienced even by modernizers such as Zeng Guofan, to reconstruct the academies and libraries lost in the Taiping Uprising and reinstate traditional studies, was ultimately felt more strongly than the need to modernize. Rather than consciously turning towards western knowledge, the preservation of what were viewed as traditional practices was given priority. When modernization resulted in conflict with established practices, as for example with the introduction of a steam tugboat to tow coal-barges from the Kaiping Mine in 1883, the modern barges still floating were removed from service, and traditional barges requiring three times as many crewmen were reintroduced.[59]

8. CONCLUSION

Four key points emerge from the Japanese experience of the introduction of steamship technology which differ from the Chinese experience, points which would have importance in the continued development of Japanese industry. Firstly, and most importantly, informal networks of practical knowledge greatly facilitated the spread of technology. As we have seen, such networks for disseminating the new knowledge do not appear to have come into existence in China during the mid-nineteenth century. Secondly, among the Japanese engineers who struggled to master the new techniques we find a number of traditional artisans who did not start by studying scientific knowledge, but initially learned by experience, bringing their traditional skills into full play. In China, even where skilled knowledge was available, it was not put to full use, and the use of traditional artisans in the study of new innovations does not appear to have occurred until the 1870s. Thirdly, since the greatest part of the work was achieved in Japan without foreign assistance, the language used for recording progress and failures was Japanese; this made the instruction of these techniques to other Japanese engineers easier and prepared the way for the wider introduction of this technology to the Japanese public. In China, despite the existence of Hobson's *Bowu xinpian,* conceptually speaking, steamship technology and other modern western inventions appear to have remained fundamentally foreign, and alien to Chinese sensibilities. Fourthly, and finally, the Japanese did not directly introduce a large scale technology, but progressed gradually, solving each sort of problem as it arose. They experimented in the small-scale construction of machinery before scaling up for practical use. In China, in steamship construction and numerous other industrial activities in the latter half of the nineteenth century, the desire to move forward more quickly than

58) See *Yangwu yundong ziliao* (Materials on the Westernization Movement) 4/33, quoted in Yang Dongliang [1988: 314].

59) See Brown & Wright [1981: 75] and Hatano [1967: 23].

engineering competence allowed, resulted in ventures which were often over-dimensioned from the start. The results proved to be unsatisfactory, leading to the necessity of relying upon imported products, which in turn delayed the development of domestic industrialization.

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