ENGINEERS AS PATENTEES AND THE CULTURES OF INVENTION 1830-1914 AND BEYOND THE EVIDENCE FROM THE PATENT DATA

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1.- Introduction. Patents and Engineers.

Too many generalisations about patents have been based on the very early years of intellectual property protection. Very little detailed study has centred on the years of patent reform, when systems began to modernise from around the 1830s. It is from this point that patenting becomes more common amongst leading industrial nations, more technically informed, and accelerates enormously as part of technological systems. Recent work has begun to unravel the workings of patent systems in the years of the later nineteenth century and the twentieth century[1]. With the larger number of patentees at work from the 1830s it is possible to identify occupational and regional groupings, and to identify cultures of innovation in particular cities or towns. From such material it becomes feasible to generalise a little about the emergence of engineers amongst patenting innovators, and to base such general remarks upon fairly broad-based data rather than selected, heroic engineering individuals, or specific successful firms and enterprises. Although such work is yet at an early stage, the present paper attempts to distil some generalisations based on a fairly broad range of material relating to patent systems in the years approximately 1830-1914, together with use of more conventional institutional and industrial data. How far does such varied material advance our understanding of the emergence of engineering as a profession? How far may single models of 'professionalism/professionalisation' enable cross-national comparisons of the emergence, character and social status of engineers?

1 INKSTER, Ian (2003a) "Patents as Indicators of Technological Change and Innovation – An Historical Analysis of the Patent Data", *Transactions of the Newcomen Society*, 73, 2, 179-208.

2.- Artisans and Engineers. Patent Transitions.

The British patent data would identify the rise of the innovating engineer as taking place in the period of liberal reforms, approximately 1830-1850[2]. Of total British patentees for these two decades, some 37% were from skilled trades groupings, 25% were self-styled engineers, 22% were self-styled gentlemen and esquires, with another 10% as mostly small-and-medium-scale manufacturers[3]. However, some great innovative centres illustrated a much higher proportion of engineers –thus Manchester at 41%. Interestingly, in the six major industrial counties of the north and midlands, where patenting was very intensive, 40% of patentees were tradesmen and artisans, some 28% were engineers, 18% manufacturers and 10% were classified as gents. So in this period the distribution of engineer innovators[4] varied significantly between regions, and we might suggest that in industrial areas such variation related mainly to the transitions involved between individuals as they moved from either tradesman to manufacturer status (as in Birmingham, where 26% of patentees were manufacturers) or from tradesman to engineer (as in Manchester)[5].

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2 Unless otherwise stated all patent data up to 1851-1852 is taken from the work of patent officer Bennet Woodcroft, compiled mostly in the 1850s. Material from 1855 to 1914 is derived from the original British patent applications, each one of which has been sighted and summarized in an EXCEL spreadsheet system. All social data is taken from complete analysis of the years 1852, 1855, 1860, 1865, 1870, 1875, 1880, 1881-1882. All other data unless mentioned is derived from data in *The Commissioner of Patents Journal,* annually from 1852 to 1883.

3 These and other occupational summaries are based on data as entered by patentees themselves, and are both incomplete and inconsistent. Every effort has been made to check data via internal consistency, directories, and other means, especially for labels such as engineer and gentleman and manufacturer. But patentees were vexatiously frivolous creatures –take Alexander Parkes of Birmingham (below) who between 1841 and 1852 applied for several patents across the range of electro-depositing and metallic alloys, metal extraction and smelting, preparing gutta-percha and india-rubber solutions, and described himself variously as artist, experimental chemist, chemist, and engineer. However, inspection of directories etc shows that Parkes was indeed moving upwards from artistic use or decorative applications of new electrolytic processes to manufacturing as a chemist.

4 In our patent survey, there are at least 175 different labels for the engineering category! This is not so unmanageable as it may seem, for by the 1860s there were around 1.000 patents annually from such groups, some 85% plus of which came from the six major sub-categories of (in order numerically) Engineer, Civil Engineer, Machinist, Mechanical Draughtsman, Civil Engineer and Patent Agent, and Consulting Engineer. The latter category grew sharply in the later 1860s to around 15 per cent of the engineering total patentees in 1870.

5 INKSTER, Ian (2003b) "Artisans de la Découverte. Modèles Britanniques et Internationaux d'Innovation Technologique 1790-1914". In COQUERY, N.; HILAIRE-PEREZ, L.; *et al* (eds.) *Artisans, industrie. Nouvelles révolutions du Moyen Âge à nos jours*, Cahiers d'Histoire et de Philosophie des Sciences, 52, ENS-éditions, Lyon.

It is noteworthy that the emergence of engineer innovators in large numbers coincided with the genesis of engineering associations and organisations, with unionisation, and with the development of many more factory locations for engineering skills. In November 1824 the first branch of the Steam Engine Makers' Society was formed in Liverpool, and by 1826 there were five branches. In restrictive political and legal circumstances such societies were but a fraction of the general movement towards engineering association: "Smiths, millwrights, iron-and-brass-founders, mechanics, engineers and machinists were struggling, sometimes together, sometimes in craft separation, to form societies or clubs which would provide mutual assistance in times of unemployment, sickness, old age and death"[6]. More discreetly, prior to the repeal of the Combination Acts in 1824-25, such association was unionism in disguise. From that time engineering organisation began to overtake that of the millwright and the smith, and the 1830s saw a great swathe of trade unionism[7]. It must also be emphasised that in these years the engineer was in full partnership with wrights and smiths, and not in competition or substitution. Newer self-acting machinery had by no means reduced the demand for fitters, joiners, pattern-makers and smiths, and the working of machinery such as slide lathes required a goodly supply of trade skill. A Manchester association of 1840 was named the Five Trades of Mechanism, incorporating millwrights, engineers, iron-moulders, smiths, and mechanics as one interest group. This became the genesis for the formation in 1851 –the year of the Great Exhibition and of the beginning of major reform in the Patent Office– of the Amalgamated Society of Engineers, Machinists, Smiths, Millwrights, and Patterns-Makers. Within six months the society boasted 9.000 members in 100 branches.

The years 1850-1870 were those of the new predominance of engineering innovation. At the national level, 42% of patentees were now engineers and

6 JEFFERYS, James B. (1945) *The Story of the Engineers,* London, Lawrence and Wishart, 17.

7 The most important examples were The Society of Friendly Boilermakers, Manchester 1834, The Amalgamated Society of Metal Planers in 1836, and a greater amalgamation that formed the Journeymen Steam Engine and Machine Makers' Friendly Society, or the Old Mechanics with 3.000 members by 1838, branches of which met in public houses throughout the industrial regions, taking on something of the secrecy and organisational characteristics of Freemasonry or Oddfellowship. Even in the 1840s the trade union role of such associations was limited, and wages for engineers varied throughout the nation from perhaps 24s. to 34s. a week in London to 18s. to 20s. in Northumberland.

professional patent agents, 20% were manufacturers, and 10% remained amongst the more traditional skilled trades.

Table 1. Engineer Patentees in Birmingham - Breakdown of Occupations

	1855	1860	1865	1870	**TOTAL**	%
Engineer	17	24	16	4	**61**	**46,56**
Machinist	12	4	10	8	**34**	**25,95**
Mechanical Engineer	3	1	6	4	**14**	**10,69**
Civil Engineer	2	0	3	2	**7**	**5,34**
Tool Maker	1	0	0	2	**3**	**2,29**
Chemist	1	0	1	1	**3**	**2,29**
Engineer and Machinist	0	0	2	0	**2**	**1,53**
Engineer, Surveyor and Land Agent	1	0	0	0	**1**	**0,76**
Press Tool Maker	1	0	0	0	**1**	**0,76**
Machinist and General Tool Manufacturer	0	1	0	0	**1**	**0,76**
Mechanical Draughtsman	0	0	1	0	**1**	**0,76**
Metallurgical Engineer	0	0	1	0	**1**	**0,76**
Electro Metallurgist	0	0	0	1	**1**	**0,76**
Gas Engineer	0	0	0	1	**1**	**0,76**
TOTAL	**38**	**30**	**40**	**23**	**131**	

A huge increase in patent agents was associated with a more formalised, professional patent system, one geared more to the needs of engineers than to those of tradesmen and manufacturers[8]. In these years engineering patenting was more equally spread throughout the country, though with Manchester and London showing slightly greater concentrations of engineers. In the second case this was due to the heavy metropolitan presence of patent agents. The major exception was Birmingham, whose predominant structure of

8 The lowering of direct and opportunity costs of patenting after 1851 of course stimulated all classes of technical skills. What is meant here is that the introduction of maintaining fees, clarification by examination of the notion of 'true and first inventor', the formalisation of 'communication applications' (by an order of 1859), and the filing of detailed specifications, all combined to give something of an increased edge to informed engineering patenting. See HULME, E.W. (1909) *Early History of the English Patent System*, Boston, Little and Brown.

small-scale manufacturers meant that engineers as patentees represented only 22% of the total. This contra-tendency lowering of the engineering proportion in Birmingham was almost certainly due to the great social transformations in that city that were centred on the upward mobility of artisans and tradesmen as they began to *manufacture* patented metal and other products on their own account[9]. Such urban social milling possibly influenced the very label 'engineer'. In London or Manchester the term was more likely to represent the general civil and mechanical engineers. In Birmingham, 62% of this category was composed of self-styled general engineers, whilst the rest were composed of machinists, tool makers, mechanical draughtsmen and electro-metallurgists, many of whom would have depended on industry-specific skills rather than generalised engineering training.

The years of engineering prominence amongst patentees were also those in which engineering associations adopted more fully the role of trade unions, defeating major employers from 1851 onwards. Major employers in dispute with engineers included such leading inventor-patentees as Joshua Field, Henry Maudslay, Joseph Whitworth, and John Rennie. Strengthened association arose primarily from the sheer growth in numbers –if in 1841 there were some 32.000 persons engaged in the manufacture of engines and machines, by 1891 this figure had reached over 250.000[10]. Increasingly the leading firms were now specialised in different sections of the engineering industry, but the growth in the number of small-sized firms depended on a second-hand market in machinery that allowed a proliferation of jobbing, contract and specialised work, providing accessories and components.

Prior to 1850 the great majority of patent partnerships were either between two or more engineers, between artisans and tradesmen, between engineers and artisans, and between artisans and manufacturers. But the small number of partnerships between engineers and gentlemen should not be ignored, for they often involved important inventions, as in the cutting and shaping machinery of gentleman John Spear and engineer Joseph Whitworth in Manchester. In other important cases engineers from one production site came together in a series of innovations, as in the case of those of the Vulcan

9 See further below.

10 Clearly, estimates of the number of engineers depends entirely on the definition of the engineer –thus Roderick Floud used membership of the Institute of Mechanical Engineers to judge that supply kept pace with the growth of firms; see FLOUD, Roderick (1967) *The British Machine Tool Industry 1850-1914,* Cambridge UP, Cambridge.

Foundry, Warrington concerning improvements in boilers. In the industrial county of Lancaster, 47% of all partnerships involved engineers, machine makers, millwrights, and mechanicians. The evidence of these early partnerships suggests that the strong development of engineering innovation owed much to a culture of self-help and information diffusion within specific urban sites.

From the 1850s partnerships still illustrate the importance of engineer-artisan cooperation in innovation –so George Collier of Halifax was in partnership with many machinists and tradesmen, and the well-known engineer Joseph Roberts of Manchester enlisted the expertise of local power loom workers and overlookers. But such cases were now joined by partnerships composed of engineers who were family members and enterprise owners, such as the Fairbairns and Woodwards of Manchester or the Dewhursts of Bradford. Of a total of 1.882 partnerships amongst patentees in the four years 1855, 1860, 1865 and 1870, 39% involved engineers.

We may identify the most competitive of the innovating engineers by turning to British patent lodgements overseas. Thus up to 75% of British lodgements into the Belgian patent system in the 1850-70 period were partnerships, mostly of engineers with manufacturers. Amongst such technology transfers by engineers were a group of novel products such as saccharine or artificial fuels. But much of such activity centred on the central processes of the British manufacturing system –steam engine parts, steam hammers, cotton finishing machinery and so on. It seems to be the case that engineer-manufacturer partnerships served to incorporate industry-specific skills into engineering innovation, as in the cases of Bradford-based Jacquard loom manufacturers or Bolton-based spinning machinery makers. In a British colony, such as that of Victoria, British engineer innovators quickly fastened on to the targeting of specific technological niches –of 35 foreign engineers who applied for gold processing patents in the 1860s, 46% were British and 29% American. The next decade witnessed a surge of British patenting into Victoria in assaying, preparing, and separating gold and other ores[11].

11 Between 1848 and 1918 some 87.000 patent applications were made in the Australian colonies, for which see INKSTER, Ian (1990) "Intellectual Dependency and the Sources of Invention. Britain and the Australian Technological System in the Nineteenth Century", *History of Technology*, 12, 40-64.

Foreign patent lodgement also helps in the identification of differing national traditions in innovation. Thus the predominance of French patenting in Belgium was characterised by corporate innovation and by a greater activity of engineers than was the case with British lodgements. In Australasia, the main competitors of the British were the Americans, who tended not to be active inventors but assignees, nominees and communicators who had at least partially taken over the intellectual property rights of original inventors. Of the Americans, 39% were engineers and 24% were corporate by 1905. In such cases we might generalise that British artisanal innovation had been outcompeted by American engineers.

Under the unreformed system, special patent agency was in little demand. William Newton, who as an engineer began to practise as a patent agent in 1820, was an exception to the rule[12]. But between 1855 and 1870 agency grew quickly, and some 85% of the patents that involved a patent agent were lodged from London, and the metropolis acted as a vast emporium of information and expertise centred in and around Holborn[13]. By 1893 the four major patenting nations boasted 1.823 patent agency offices, of which the USA had 45%, Germany 27%, France 15%, and Britain 13%[14]. In itself this might suggest that Britain was now lagging behind other nations in the adoption of more professionalised engineering services[15]. Of the British total of 235 patent agency offices, 53% were in London. Some 34 other urban areas had at least one office, led by Manchester with 25, Birmingham with 15, and Liverpool with 12. Together with partnerships, such expert agency added to the system of information exchange amongst British innovators, and there is no doubt that this was lead by the engineers.

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12 William Newton is of especial interest as editor of the *London Journal of Arts,* which reviewed all patents annually. See *A Memoir of the Late Mr William Newton, reprinted from Newton's Journal of Arts for Aug 1861,* London, R. Folkard, 1861.

13 For the four sample years 1855-70, Holborn patenting totalled 1.353 or 25% of the London total, and of this 1.073 had been registered by patent agents, or combinations of agents with engineers.

14 *The International Directory of Patent Agents for 1893,* London, William Reeves, 1893. Of all offices listed internationally in that year, the total was 2.202, so the four major nations represented 83% of total agencies of the world.

15 An Institute of Patent Agents had, however, been formed in 1882, and an Act of 1888 gave the Board of Trade the power to establish an official Register of Patent Agents.

3.-The Culture of Engineering Invention. Training, education, and partnerships.

The growth of British engineering innovation did not depend on any system of formal education before the 1880s[16]. The founding of the City and Guild Central College in 1880 was a minor addition when compared to the traditional method of learning a trade by watching and imitating a skilled man through indentured apprenticeship or through some other on-the-job 'learner' system. Generally, at that time the workshop itself was seen as the best of all engineering schools, wherein real tacit knowledge was passed on at cost to the student/worker rather than the state/tax-payer. Nevertheless by 1891 some 150.000 science and arts students and 13.000 City and Guilds students were attending part-time instruction of some sort[17]. But apprenticeship plus some part-time education did *not* encompass the full culture of invention drawn upon and participated in by British engineers in the second half of the nineteenth century. Patenting data reveals how partnerships, patent libraries and museums, technical publications, urban associations, enterprise training, patent agents and trade organisations all combined to create an effective training and information system, one which was far closer to the specific needs of innovators than any more formalised educational system could have been[18]. From the 1851 Exhibition onwards, artisans and engineers engaged in the formation of an information system for innovation. Inventors' institutes provided patent libraries, help with applications and registrations, advice on litigation, and at times workshops, laboratories and lecture meetings[19]. Beyond the city mechanics' insti-

16 The best account of the small scale of formal education provisions even into the 1890s remains the hard work of MORE, Charles (1980) *Skill and the English Working Class, 1870-1914*, London, Croom Helm, see especially chapter 10. For an excellent survey and judgement on engineering education more broadly see chapter 9 of BUCHANAN, R. A. (1989) *The Engineers. A History of the Engineering Profession in Britain 1750-1914*, London, Jessica Kingley Publications.

17 NICHOLAS, Steve (1985) "Technical Education and the Decline of Britain". In: INKSTER, Ian (ed.) *The Steam Intellect Societies*, Nottingham, Nottingham UP, 80-93.

18 The neglect of universities should be explained. I would maintain that their impact on innovation in Britain came only after the 1880s and did not represent a substitute for the skill-and-tacit-knowledge system drawn upon by the mass of patenting innovators, including most of the engineers. See SANDERSON, Michael (1972) *The Universities and British Industry 1880-1970*, London, 1972.

19 For an example see *The Inventors' Institute, Report of the Council of the Institute Made to the First Annual Meeting 14 May 1863*, London, 1863.

tutes[20] lay local artisan clubs and lecture societies that boasted huge memberships, and these proliferated throughout the English and British provinces. The travelling lecturers who gave long courses on practical and theoretical mechanics included such men as Henry Adcock, Charles Sylvester, John Stancliffe, William Lester and Robert Addams, all of who were successful patentees. Such self-help groupings were assisted by government, not through formal education, but through the free dispersal of bundles of printed technical and patent literature to all major provincial centres, at a cost to the taxpayer of some £500.000 by 1870. The patent office library in London alone recorded 493.000 readers between 1855 and 1882.

Critics of the importance of such informal information or knowledge systems have often pointed to the difficulty of measuring their impacts on the innovation process. A study of one innovating centre, the city of Birmingham, helps to bring some colour to the overall claim that there was a significant, knowledge-based culture of innovation within and surrounding important urban sites of engineering activity.

In the unreformed system prior to 1852, Birmingham was second only to London in total patenting activity, falling behind Manchester to third place between 1852 and 1881. However, in per capita terms after 1852, Birmingham ranked ahead of both London and Manchester, but was bested by the much smaller cities of Rochdale and Nottingham[21]. We might judge that Birmingham was a leading centre of innovation throughout the period in which a more formalised engineering emerged as a predominant source of technical change. In Birmingham, where artisan invention was of especial importance during the 1830s and 1840s, so too was there a disproportionate emphasis on small metal product improvements –43% of patents related to advances in design, materials or use of equipment of such items as decanters and other glass-ware, firearms, lamps and gas-burners, woodworking and furniture making, inkstands and ornamental items etc. It can be argued that this pattern of patenting directly reflected the famous 'par-

20 The mechanics' institutes have often been seen as merely expressions of middle-class cultural dominance. That they may also have acted as providers of education and information resources to artisan and engineering innovators, has in the main been ignored. See however INKSTER, Ian (1997) *Scientific Culture and Urbanisation in Industrialising Britain*, London, Ashgate.

21 For full details see INKSTER (2003a).

cellation'[22] of Birmingham industry, the predominance of small industrial units in the small metal trades producing specialised products[23]. Despite the absorption of many such small shops in the amalgamations of the 1850s and 1860s, a leading patentee-manufacturer of the town could naturally comment in 1866 how the town's social and political freedoms were extreme because "the large number of small manufacturers are practically independent of the numerous factors and merchants they supply… in no town in England is comfort more common, or wealth more equally diffused"[24]. It was within this context that a vibrant culture of innovation continued to evolve.

Such a plethora of product innovations represented an aftermath of much earlier and very significant machine and process innovations in the city. In the later eighteenth century such local patentees as the iron masters Richard Jesson, Richard Dearman, Jonathon Taylor, William Bell and John Wright, or the brassfounders Thomas Whitehurst, John Ashton and John Marston, had registered a series of innovations in casting metals, rolling iron from pig, and stamping plated metals that together represented a significant chain of technical improvement in the locality. By the 1790s Birmingham easily outranked Manchester, Sheffield or Newcastle in the number of patent lodgements. Few of the Birmingham patentees registered themselves as engineers, the exceptions being James Watt (1784 steam engines), Matthew Boulton (1791 press), and William Whitmore (1792 mashing machinery). At this time the majority

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22 FAUCHER, L. (1845) *Études sur l'Angleterre*, vol 2, Paris, Librairie de Guillaumin, 147 quote. Regarded as fragments, the observations were published from his lectures of 1843 and 1844. The chapters on Birmingham are pp. 131-191. The Frenchman emphasised the relations of civic politics and civic capital structure: "Birmingham va nous présenter un phénomène non moins extraordinaire, la démocratie industrielle dans une vaste cité et jusque dans les ateliers que la vapeur fait mouvoir … pendant que les capitaux tendent à se concentrer dans la Grande-Bretagne, ils se divisent de plus en plus à Birmingham. L'industrie de cette ville, de même qu'en France la culture du sol, est descendue à l'état parcellaire".

23 Iron and brass work allowed for the different processes of production to be carried out in a variety of separately organised and owned workshops, although some firms did grow, such as the brass founders Robert Winfield with 800 employees in the 1860s, or Chance Brothers in the glass industry with 1.700 employees: see BRIGGS, Asa (1952) *History of Birmingham vol 2, Borough and City 1865-1938,* London, OUP, especially chapter 3.

24 TIMMINS, Samuel (1866) "The Industrial History of Birmingham". In: TIMMINS, S. (ed.) *The Resources, Products and Industrial History of Birmingham, A Series of Reports*, London, Hardwicke, 207-224.

of Birmingham patentees were tool makers, brass founders, iron founders and manufacturers, or were small masters in buckle and button making or japanning, and this pattern was not much disturbed into the 1830s. Increasingly groups of patentees were drawn from surrounding areas of the town –West Bromwich, Islington, Edgbaston, Ashted, Smethwick, and Winston.

From an early stage Birmingham associations included those designed specifically for technical innovation. The more gentlemanly clubs of the later eighteenth century, epitomised by the famous Lunar Society (1775-98), had by the 1820s given way to a culture of urban technical association[25]. So the Birmingham Philosophical Society focussed on lectures in "mechanism, chemistry, mineralogy and metallurgy", which by 1818 had "contributed in a considerable degree to the improvement of gilding, plating, bronzing, vitrification and metallic combination", whilst the contemporary Physiolectical Society had been founded in 1803 "for the purpose of improving its members in natural philosophy by lecture, experiment and discussion"[26]. Prior to the Great Exhibition the Birmingham Philosophical Institution and the Birmingham Polytechnic Institution boasted memberships of over 600 persons[27]. Active members of the Birmingham Philosophical Institution included such leading patentees and innovative industrialists as George Parsons, J.F. Ledsam, A. Follet Osler, Arthur Ryland, Joseph Wickedden, James Timmins Chance, John Percy MD, and George Frederick Muntze, several of whom delivered classes and lectures[28]. Charles Dickens for one visualised the Birmingham Polytechnic of the 1840s as working for artisans on "the principle of comprehensive education"[29].

25 The best work on Lunar remains SCHOFIELD, Robert E. (1963) *The Lunar Society of Birmingham. A Social History of Provincial Science and Industry in Eighteenth Century England*, Oxford, Clarendon Press.

26 PYE, C. (1818) *Modern Birmingham,* Birmingham, 37-38; DRAKE, J. (1825) *The Picture of Birmingham,* Birmingham, 36; *Philosophical Magazine,* 13, 1803, 86.

27 *List of the Literary and Scientific Institutions from which Returns were Procured at the Census of 1851,* Population Census of Great Britain, Sessions 1852-54, London, House of Commons, 237.

28 *Report of the Birmingham Philosophical Institution for 1836,* Birmingham, J. Belcher, 1836.

29 BIRMINGHAM POLYTECHNIC INSTITUTION (1844), *Report of the Conversazione 28 February 1844,* Birmingham, JW Showell.

Table 2. Occupations of Birmingham patentees 1840 – 1849

	No. Patentees	%
Total No. of Engineers	62	19.8
Gentleman/Esquire	25	8.0
Merchant	16	5.1
Manufacturer	81	25.8
Farmer/Yeoman	4	1.2
(Sub Total)	(188)	(c.60)
Others (mainly Tradesmen/Artisans)	126	40.1
Total	**314**	**100**

During the 1840s there was a significant increase in the number of Birmingham engineers taking out patents in machine processes –from improvements in steam engine manufacture and steam locomotion (John Jones, Henry Davies, Charles Heard Wild, the Soho Company, Emanuel Wharton, Isaiah Davies, Thomas Edwards, Thomas Craddock, George Heaton, William Baker, Charles William Siemens, Samuel Fisher) to pipe and tube manufacture, thrashing machinery, fire proofing, and printing, to bolt building, metal shaping and cutting, shearing and punching, gilding and plating, manufacture and working of metallic alloys, and improvements in planes and metal surfaces. Several such patentees were using a general engineering expertise across a field of activities, a good example being Henry Adcock of Summer Hill Terrace, Birmingham, variously a toy manufacturer, engineer, and travelling lecturer on mechanics, who brought out a varied series of patents between 1824 and 1851.

Table 2 shows the engineers amongst all occupational categories in Birmingham during the 1840s. Clearly tradesmen and artisans yet easily outnumbered the engineers, as did manufacturers, but there is no doubt that engineer innovation was now disproportionately important in significant motive power and metal process innovations. Engineers more concerned with products such as pipe manufacture, cooking apparatus, needle manufacture, or clothing, were now themselves moving into the manufacturer category, a good example being the civil engineer Richard Prosser who brought out a series of varied product innovations (piping, buttons) and had established his Birmingham Patent Iron Tube Co. at Smethwick near Birmingham by 1851[30].

30 *The Patent Journal and Inventors' Magazine*, X-XII, 5 October 1850-27 December 1851.

The engineer partnerships of this period illustrate something of the self-help character of the urban innovation culture. Engineers involved in product innovation were often in partnerships with manufactures, merchants or gentlemen, such as with machinery for button manufacture, cork cutting, tube manufacture, playing card manufacture, and so on. Engineers engaged with process innovation tended to be in partnership with other engineers[31] or with machine manufactures such as William Cosher of Cumberland Street (1841). In contrast, partnerships in product innovation were mainly between manufacturers or between skilled tradesmen.

Table 3. Occupations of Patentees in Birmingham 1855-70

	1855	1860	1865	1870	TOTAL	% of given occupations
Artisan Tradesman (Agricultural)	1	0	4	0	5	0,84
Artisan Tradesman (Industrial)	16	9	12	11	48	8,09
Commercial/Clerical/Agent	3	4	7	5	19	3,20
Engineer	38	30	40	23	131	22,09
Farmer	1	0	0	0	1	0,17
Gent/Esq	4	1	1	1	7	1,18
Instrument Maker	1	0	0	0	1	0,17
Manufacturer	82	92	77	76	327	55,14
Merchant	1	2	8	1	12	2,02
Patent Agent	1	0	0	0	1	0,17
Professional	2	4	2	0	8	1,35
Retail Tradesman	3	4	13	6	26	4,38
Small Manufacturer	0	2	2	0	4	0,67
Supervisor	0	1	1	1	3	0,51
Unknown	16	4	13	18	51	
TOTAL	**169**	**153**	**180**	**142**	**593**	

Table 3 shows occupations of Birmingham patentees between 1855 and 1870. Engineers are now second only to manufacturers. It shows the variety of engineering patentees in Birmingham from 1855 to 1870, illustrating that

31 Interestingly, this was true of Richard Prosser in his machinery patent of 1843, who as a civil engineer partnered another engineer Job Cutler (no. 9.707).

the bulk were self-described as engineers, machinists, toolmakers, or chemists[32]. What was the urban innovation culture of such a group of patentees?

From 1854 the Midland Institute provided facilities expressly for artisans, these including science and metallurgical classes, a laboratory and workshop and a library and lecture courses. Some 45% of students were artisans and apprentices, perhaps 20% engineers[33]. The Institute took over laboratory apparatus of an older scientific association, and provided evening classes in physics and chemistry under the Edinburgh-trained educationalist Mathew Williams. The chemical and engineering laboratory work was introduced at a special charge of £2 per annum at Cannon Street and was designed on Faraday's principles as outlined in his *Chemical Manipulation*. About 1860 Williams started the Chemical Club at the Institute and then the Institute Scientific Society in 1872, which from the first took on an experimental orientation. Other members of this group included educationalists and patentees such as Edwin Smith and Samuel Timmins. From the mid-1890s the focus switched to graduate chemists and engineers, and was designed to render them more practical and technical in order to fit more closely the requirements of real manufacturing production through demonstrating "how theories and how books are often wrong, how a process or system which may answer perfectly well in one locality may be a dead failure in another"[34]. In this the urban associations were adapting to trends both in manufacturing demands and educational provisions.

A good example of the latter was the Mason Scientific College from the 1880s, which by its deeds of 1870 was to be "specially adapted to the practical, mechanical, and artistic requirements of the manufactures and industrial pursuits of the Midland district, and particularly the Boroughs of Birmingham and Kidderminster, to the exclusion of mere literary education and instruction"[35]. Intended as a provincial university for skilled workers, the

32 Percentage figures based on sample years 1855, 1860, 1865, 1870, these yielding 610 Birmingham patents, representing 92% of the Warwickshire total. The Birmingham 4-year total compares to the 439 patents for all 20 years 1830-1849.

33 TANGYE, Richard (1889) *One and All. An Autobiography*, London, SW Partridge.

34 TUCKER, Alex E. (1902) *The Birmingham and Midland Scientific Society, Feb 12 1902*, Birmingham, EC Osborne. One visitor to the lab, who was acquainted with Williams and came to chat and experiment on fulminates and other explosives was GA Pieri, the associate of Orsini in the attempt to assassinate Emperor Napoleon III on 14 January 1858, for which both were guillotined.

35 *The Mason Science College Calendar for the Session 1884-85*, Birmingham, Cornish Bros, 1884.

engineering course emphasised that "in the laboratory the student makes experimental investigations of the properties of Tools, Machines, and Materials, such as he can have no opportunity of making during an apprenticeship at works", this reducing a necessary apprenticeship by some two or three years. Special lecture courses on technical subjects were designed as "suited to Works' managers, foremen, draughtsmen, and Apprentices". Textbooks for engineering students to study included a long list of advanced trade manuals, books on specific areas of mechanics by patentees and leading engineers (e.g., those of Alexander, Rankine, Holtzappffel, Northcott, Fairbairn), the catalogues of manufacturers, as well as the substantial volumes of theorists such as Clerk Maxwell.

A prime resort of engineering inventors was to the Patent Library within the city's Reference Library. By 1870 it harboured some 2.500 volumes of patent literature, and in that year, of 124.368 issues for the library, 3.360 were of patent literature, 15.237 were of volumes of books in the arts and sciences[36]. Most popular technical volumes apart from the patent literature itself were Cottingham's *Metal Worker's Director* (1824), Percy's *Metallurgy* (1861-70), and Faraday's *Electricity* (1839-55)[37]. Of over 58.000 readers' tickets issued in 1870 alone, some 46.000 went to individuals between the age of 14 and 30, and of these some 2.893 were issued to engineers, 3.336 to metal smiths of some description, 1.196 to engravers, 1.450 to chasers and embossers, 1.316 to printers, 730 to brass-founders, 584 to platers, 507 to tool makers, 468 to iron trade workers, 430 to gun makers, 405 to fitters, 375 to tin and iron plate workers, 316 to other metal trades, 137 to electro-metallurgists, 108 to pattern makers, 101 to carvers and gilders, 282 to workers in the glass trade, 147 to machinists[38]. Clearly, patent and other practical technical literature was studied systematically by the city's engineers and artisans. Table 4[39] lists the num-

36 BIRMINGHAM LIBRARIES (1870) *Ninth Annual Report of the Free Libraries Committee, 1870*, Birmingham, Martin Billing, 18-46.

37 The other two works are well known to historians of technology, but COTTINGHAM, L. N. (1824) *The Smith and Founder's Director. Containing a Series of Designs and Patterns for Ornamental Iron and Brass Work,* London, Cottingham, with its 82 plates of designs on a large scale was perhaps the most representative as technical reading in Birmingham. The author was an architect of 66 Great Queen Street, Lincoln's Inn Fields.

38 This list fairly certainly excludes all substantial manufactures, which were listed separately as such. In 1870 these totalled 712 manufacturers and 491 factors and merchants receiving readers tickets.

39 Derived from annual reports for these years.

bers of annual issues for patent literature and for volumes of arts and sciences between 1870 and 1897.

Table 4. Issues from Birmingham Reference Library 1870-1897.

Year	Patent Literature	Arts and Sciences
1869	4.468	17.368
1870	3.360	15.237
1877	4.438	32.987
1880	4.658	47.841
1892	27.359	46.130
1893	42.843	49.912
1897	53.950	83.903

It seems evident that the 1880s and 1890s saw a great rise in the use of patent literature as a source of specific technical information in Birmingham. Mill and Marx remained amongst the most popular of books issued by the reference library, but were closely followed by the popular representations of the machinofacture culture –Rivington's four volumes on *Building Construction*, Larkin's *Brass and Iron Founder* (1855-1866), Thorpe' *Dictionary of Applied Chemistry* (1885-1893), Hiorns' *Iron and Steel Manufacture* (1885-1895), Ripper's *Machine Drawing and Design* (1886-1889), or *Watt's Electro Deposition* (1886-1889)[40]. These volumes were by no means light reading. Who was making what of them? Amongst the technical readership in 1891 were some 1.400 engineers[41], the rest of the total of 9.164 readers being mostly composed of a variety of skilled tradesmen, small manufactures, female machinists and telegraphists, and students[42]. By this time some engineering works were providing their own training and educational facilities, an example being the

40 The most popular of the technical journals included *The Technologist* from 1851, *Annual Records of Science and Industry* from 1872, *The Practical Mechanics' Journal* from 1848, the *Repertory of Arts and Manufactures* from 1794, the *Repertory of Patent Inventions* from 1825, and the *Art Workman* from 1873.

41 This term including die-sinkers, tool makers, cutters, bolt makers, engravers, electro-platers, and lithographers.

42 *Annual Report of the Free Libraries Committee Birmingham, 13th 1891*, Birmingham, Hudson and Son, 1892. It should be noted that the figures relate to numbers of separate readers, rather than merely issues. Many of the 2.727 students would have been destined for engineering work.

machine tool and hydraulic-engineering firm of Tangye Bros at their Cornwall Works near Soho. Classes were provided for machine construction and drawing, and mathematics, as well as lectures on subjects "bearing immediately on daily work and affording information on the materials and processes of manufacture". It was argued that, given that these and other establishments rewarded the intelligent workman with promotions to foreman and management positions based on qualities that were "always the result of superior knowledge", so in areas of great technical change all may have a worthy ambition. The motto above all others was that to "be a Successful Mechanic you must be a Mathematician. Unless you can Conquer the Mathematics of this Trade you will always have to drudge at the hardest Work done. With a Thorough Practical Knowledge of the Work and the Principles Underlying it you will soon rise above the Lathe and File"[43].

There seems to be good qualitative evidence that the rise of engineering innovation in Birmingham was strongly associated with increased facilities for knowledge circulation and testing, and for basic technological training, that went well beyond our familiar distinctions between the tacit knowledge of apprenticeship and the trades on one hand, and a higher scientific training on the other. Between such extremes lay an urban culture of information circulation that was motored and tested by a competitive culture of innovation within one of the most intensive patenting cities in the world.

4.- Patenting Patterns and the Engineers.

All patent systems suggest something of the emergence of engineering innovation. The explosion of international patenting at the end of the nineteenth century indicated the massive diffusion of key technologies, especially in metals and chemicals. Some 3,4 million patents had been granted worldwide by 1912, of which 31% were American, 13% were French, 20% were British and British dependencies, and 8% were German. Outside Europe and the United States patenting amounted to little more than 7% of the world total. So here we may identify a massive process of technology creation and flow between the members of a small group of nations. Between 1905 and 1910 alone, Germans were granted over 25.900 patents in other nations, this aggressive patenting followed by the Americans with 25.200, and the British with

43 TANGYE (1889).

16.800 foreign lodgements[44]. Such a rapid acceleration in the flow of technical knowledge put massive pressure on the knowledge and engineering systems of all recipient nations, and perhaps explains something of the great flurry of state activity in the formation of polytechnic and other formal training institutions and in the migration of technologists between such nations and between them and their new colonies. In the latter, large civil engineering structures (railroads, bridges, aqueducts, tunnels, dams, harbours, arsenals) were part and parcel of the process of territorial conquest or expansion. Clearly enough, engineers were both creators and recipients of this flow of technical information and challenge, and in nations adopting a strategy of late industrialisation through technological catch-up the engineer became a strategic element of overall planning in a way that had never been the case amongst the earlier starters of post-Napoleonic Europe. In addition, the association of technology transfers-in with the opening up of nations to a flurry of new ideologies and political movements meant that *the industrialising state looked for an institutional formula that combined a good supply of qualified engineering skill with a control over the political economy of such skill*[45]. The free culture of innovation, a "multiplication of Birminghams", was neither feasible nor desirable, and the industrialising state was more likely to site engineering training and production within specific parts of a more *enclavist* development process. It seems probable, then, that with later developers and greater government intervention, the transition from artisan to engineer became far more obvious and rapid, both because speedy interventions tended to destroy handicraft and bi-employment industries –e.g. the *kustarni* industries of late nineteenth century Russia– within which the older artisan skills and innovations thrived, and because engineers could be more formally isolated, catered for, trained and certificated in government institutions. So there would be a greater tendency to speedy formalisation and differentiation in later developers. In cases such as Germany, Russia or Japan we might expect a high degree of discontinuity in the replacement of craft with engineering innovation within the patent systems of such nations.

In contrast, in earlier developers the rise of new middle-class consumption patterns lead to a wider range of industrial consumer goods being produced

44 See table 2, INKSTER (2003a), 181.

45 INKSTER, Ian (2002) "Politicising the Gerschenkron Schema: Technology Transfer, Late Development and the State in Historical Perspective", *Journal of European Economic History,* 31, 45-87.

as a response to higher real incomes in the years 1850-1914, a prime example of these being the host of household and building products associated with new aesthetics, the arts and crafts movements, and *art nouveau* –these all tended to increase the demand for both artisanal workshop production and artisanal inventiveness[46]. On the other hand there were very important counter-forces, which may well have served to disguise such underlying patterns between forward and backward industrial systems. Thus, of nearly 800.000 apprentices in late industrialising Germany, 70% were employed in smaller firms but many of these at a later stage in their careers transferred into the modern, large-scale, engineer-dominated industrial firms. That is, a speedily modernised professional engineering system was riding on the back of an older, apprentice tradition in the handicrafts[47].

In terms of the differential training components of engineering between industrial nations, Roderick Floud long ago asked us to look beyond the simplistic David Landes distinctions between state aid and private initiative in the general industrial economy[48]. Germany had polytechnics because of high rates of government investment in industry, England hardly managed science in the schools because of the greater influence of private initiative in the economy. Floud is more sophisticated in transplanting to this phenomenon some analysis of types of human capital formation, derived from the original distinctions of Gary Becker[49]. Employers invest in firm-specific knowledge for it is of use to them only. Employees invest in general training because it is of use to them in any firms within the industry and possibly beyond –thus in apprenticeship they accept lower wages or pay premiums, and so on. In state systems such as Germany, the state takes the risk of much of industrial production, especially at the hard edge of new imported-technology industries, and thus is more likely to invest in general training at its own cost (thus polytechnics etc)[50]. I would

46 QUIMBY, Ian M.; EARL, Polly A. (1974) *Technological Innovation and the Decorative Arts*, Charlottesville, University Press of Virginia. See also, INKSTER, Ian (2000) "Patent Counting: Machinofacture and the Culture of Industry", Art Nouveau Conference 23-25 June 2000, *Conference of the Exhibition Art Nouveau 1890-1914*, London, Victoria and Albert Museum.

47 LEE, J.J. (1978) "Labour in German Industrialisation". In: MATHIAS, P.; POSTAN, M.M. (eds) *The Industrial Economies, The Cambridge Economic History of Europe*, VII, Part 1. Cambridge, 442-91.

48 LANDES, David (1969) *The Unbound Prometheus*, Cambridge.

49 BECKER, Gary S. (1980) *Human Capital*, Chicago, 2nd edition.

50 FLOUD, R. (1984) "Technical Education 1850-1914: Speculations on Human Capital Formation", *Dicussion Paper Series*, no.12, Centre for Economic Policy Research, London.

go further and argue that the state is both faced with a greater array of complex machine techniques all-at-once, as in a Gerschenkron-type model, and is less concerned generally with direct profit and loss accounts –that is, the political economy of state decisions in late development is not at all comparable with the individual calculations of either firms or their employees in more mature industrial economies where more or less competitive markets lead decisions over labour training[51].

5.- Conclusions. Professions and Identities.

Is it possible to compare the process and timing of emergent engineering groups across nations in terms of a single "professionalization" model[52]? In the Anglophone tradition, professionals are those who boast superior specialist training or education, who command entry into their occupation, but whose behaviour is subject to codes of conduct laid down by central bodies or professional associations[53]. Whilst historians might find some features of professionalisation and professionalism difficult to identify, especially those relating to ethics and to client relations, others seem amenable to comparison –thus in some nations central bodies linked to government might be decisive in awarding status and legitimacy, in others such awarding may be the task of non-government, voluntary associations. Clearly, assessing engineering in terms of a number of such criteria might be feasible, although the demarcations required would render all such judgements highly problematic[54]. Thus in the case of our British engineers we could point to such criteria as full-time occupation, formalised training systems, emergent gate-

51 For the Japanese case of late development this complex process involving cultural engineering, human capital formation, and technology transfers is worked out in INKSTER, Ian (2001a) *The Japanese Industrial Economy. Late Development and Cultural Causation,* London, Routledge; and INKSTER, Ian (2001b) *Japanese Industrialisation. Historical and Cultural Perspectives,* London, Routledge.

52 This is not yet a redundant query despite the decline of professionalisation as a theme amongst most social historians after the 1970s. In particular, the status of any group as professionals is central to notions of identity, as Buchanan (1989: 12-27) illustrates for engineering.

53 See GREENWOOD, E. (1957) "Attributes of a Profession", *Social Work*, 2, 44-55; PARSONS, Talcott (1958) "The Professions and Social Structure", in his *Essays in Sociological Theory*, Glencoe, Ill.; BEN-DAVID, J. (1963-1964) "Professions in the Class Structures of present-day societies", *Current Sociology*, 12, 247-298; FREIDSON, E. (1986) *Professional Powers: A Study of the Institutionalization of Formal Knowledge,* Chicago, University of Chicago Press.

54 The engineer W.E. Wickenden in 1950 listed 6 characteristics or criteria: possession of a body of knowledge, an educational process, standards of qualification, standards of conduct,

keeper functions, and autonomous regulation through association, as all emerging alongside the rise of the patentee engineer after 1850, and particularly after 1890. But other elements of professionalisation are far more difficult to depict or to compare across systems –these especially relating to the development of professional consciousness associated with self-control regulated by ethical codes. Even between nations of *similar* development or adjacent culture such comparisons are liable to major criticism.

Between nations of disparate development and culture such problems are hugely magnified, especially if we are prepared to take into full account the two massive historical disjunctions of the later nineteenth century –those associated with the Gerschenkronian complications of late development briefly sketched above[55], and those forced by the phenomenon of late nineteenth century colonialism. We would need a model that takes account of power relations and resulting institutional formations, and especially the likely contrast between nations of earlier development and of later development. It is too easy to confuse or conflate state structures and real power systems. Late developers appeared to have strong states and sturdy state intervention –thus centralised bureaucracies, thus gymnasia and polytechnics. But this misses the point. More industrialised early starters such as Britain or the USA, or France or the Low Countries, possessed strong states but *highly implicit state structures*, the latter depending in turn on high degrees of civic authority and civil understanding. In early developers, policing was merely more implicit or covert than in more centralised regimes. This difference may well have been central to differences in the history of engineering professionalism.

However much colonialism was an institutional evolution of industrialism, for the colonised it often meant fairly sudden disjunctions accompanied by loss of effective economic and cultural sovereignty. Yet, the colonial experience is perhaps best considered as dividing into two types. On the one hand regions of recent white settlement, such as the Australian colonies, New Zealand or South Africa, faced a barrage of technology transfers through specific colonial

recognition of status by peers or the state, an organisation of progress and advance, rather than one only of commercial monopoly. See his speech as quoted in LEWIS, R.; MAUDE, A. (1952) *Professional People*, Phoenix House, London, 54.

55 For the best brief summary see GERSCHENKRON, Alexander (1962) "Postscript", in his collected essays, *Economic Backwardness in Historical Perspective. A Book of Essays*, Cambridge Mass., HUP.

mechanisms, which competed with transplanted engineering in the colonies and forced various forms of response and adjustment. Such dependent yet developing systems illustrated particular models of engineering professionalism. But secondly, and far more profoundly important to the history of the twentieth century, colonised regions of old settlement, dense population, and established value systems, suffered a process of underdevelopment, as pockets of indigenous skill and energy were usurped by the new forces of the metropolis. Here metropolitan engineering prowess and personnel dominated the scene at the expense of original or indigenous handicrafts and trades skills. Admitting great differences even within these two groups[56], it is surely clear that *between* such groups there must have been vast contrasts in the positions of the engineers and in the processes of engineering professionalisation.

In the end, then, comparative studies of the emergence of the engineering profession as a component or context of the formation of an engineering identity in the years prior to 1914 will have to take some notice of the following simple typology:

1. *Nations of early industrialisation*, where the process of professionalisation might be expected to be drawn out over time, confused, voluntary and as a response to civil demands of many sorts, variable between regions and even cities, and strongly connected to the innovative roles of engineers and to systems of intellectual property protection. Our study of the British case points to evolution of institutions rather than to their sudden transformations, to urban and provincial pluralism rather than to formalised centralism of training, innovation or organisation, and to a long co-existence with more traditional handicrafts, which continued to generate and nurture the tacit skills required of many product innovations for some years to come.

2. *Nations of later industrialisation*, where the emergence of the engineer might be expected to be more discontinuous, associated with the response to

56 We readily admit to the variety of manners in which complex societies became colonised, particularly in terms of the extent of co-option of indigenous elites and other groups. Nevertheless, there appears to be a robust contrast between colonisation of established or large populations, and settlement by white populations of sparsely populated regions, in which the indigenous peoples are dispersed, reduced, and eventually defined as beyond the pale of the "new" colony –thus by the early twentieth century the national accounting processes in such regions might entirely omit the excluded indigenous peoples when, for instance, estimating the income per head or living standards of the population– thereby white colonies posted very high standards of living even in comparison to those of their "mother" countries.

a great host of advanced, foreign technologies and civil engineering structures (e.g. railroads, large road systems, docks and harbours), and linked closely to both formal general technical training institutions such as polytechnics and professional associations, and to government initiatives, especially in heavy and military-oriented new industries.

3. Nations of colonial recent settlement, where the engineers of the new periphery originated in system 1 primarily, and where the institutions and standards of the engineers are transplanted from system 1 in the main. As with system 2 such engineers will be in demand because of processes of technology in-transfer.

4. Colonial nations of large, indigenous, non-European populations, where indigenous engineering must fight for space with engineers from systems 1, 2, and 3 above. Here there are many battlegrounds, losers, and winners.

In all four types of system (admitting much variety within them, especially systems 1 and 4) the formation of engineers was surely related to processes of innovation and systems of property rights? We have suggested here that in *system 1*, engineers emerged from artisanal groupings within an existing but reforming system of intellectual property rights. The lodging of patents was a very important process, both commercially and as a means of marking skill, presence, authority, legality, and professionalism. This was especially so pre-1880s when systems of formal certification or qualification were lacking or rudimentary. In contrast, *in system 2* nations, patent systems were designed or intended more as institutions of technology transfer, as international information systems. Here engineers were invaluable as agents of global search, but also as agents of invasion –patent systems could be used aggressively to lodge technological claims into system 1 nations, where the commercial gains might be most lucrative. Germany exhibited such tendencies in dyestuffs industry patenting prior to 1900, particularly with regard to the technical invasion of the British patent system[57]. Such activity required protection, high levels of information, commercial acumen, and the assistance of official systems of information, standardisation, and regulation. All of this impacted centrally upon engineering as a profession.

The professionalisation of engineers in *system 3* nations was likely to be some dependent reflection of processes occurring in system 1. Here a more

57 The Coal tar Colour Industry in Germany and England', *Nature*, 12 December 1901, 138-139.

amateur profile was likely to survive for longer. But open patenting meant that the engineers on the periphery faced immense competition from floods of advanced patents and associated technologies from the engineers of other nations, especially of system 1 and especially from nationals of the imperial "home" centre itself. For most of our period, engineers in system 4 areas were consigned to backwaters as the resident engineers from system 1 –and especially from the colonial "home" centre– flooded their economies and their patent systems. During the twentieth century a syndrome of underdevelopment was well under way, and was associated strongly with the spread of patent systems globally, as shown in Table 5, which depicts the spread of patent systems in the years 1911-1973. Most researchers in this field have concluded that international patenting in the years circa 1914-1970 closely reflected the patterns of development in global commerce and production. Most patenting lodged in nations of system 4 originated in nations 1 and 2, and this directly impinged on the possibilities for legitimate, protected innovation for indigenous engineers, and thus upon their status and rewards within their own countries. Vaitsos argued that it was through patent legislation and the development of patented knowledge by foreign firms that "a technological monopoly is turned into an institutional one" within the economies of twentieth century underdeveloped nations[58].

Table 5: The Spread of National Patent Legislation 1911-1973

Nations	1911	1915	1934	1958	1967	1973
Developed Market Econ	17	19	20	20	20	20
Socialist Countries	4	7	7	8	8	8
Southern Europe	3	4	4	4	4	4
Developing Countries	28	42	44	60	83	85
Others	1	1	2	4	4	4
Total	**53**	**73**	**77**	**94**	**118**	**120**

Thus we have turned full circle. In an early starter such as Britain the patent system, as an imperfect system of intellectual property rights, acted so

58 See VAITSOS, C. (1974) *Intercountry Income Distribution and Transnational Enterprises*, Oxford, quote p. 18; FREDERICO, P.J. (1957) *Distribution of Patents Issued to Corporations, 1939-55;* Subcommittee on Patents, Trade Marks and Copyright of US Senate, 84th Congress, Washington.

as to provide something of protection and information to a nascent engineering profession. Engineering innovation was sited in diverse localities, and served to bring to commercial operation a long series of fundamental breakthroughs in technology. In the group of later industrialising nations prior to 1914 much of the industrialisation process involved a relatively telescoped period of technology transfer, in which competing patent systems served to flood engineering capacities in receiver nations. The resultant increase in engineering capacity was swift and associated with a more formal siting of innovation projects in major enterprises and civil projects. After 1914, the international patent system was increasingly associated with a vigorous growth of industrial capitalism alongside a dynamic, negative process of underdevelopment in outsider economies whose plans for development were fatally predicated on processes of technology transfer that, in the main, failed[59]. Such dependent technological growth did not encourage the emergence of a high level of engineering capability in most parts of the world, and underdevelopment became a syndrome composed of institutions, attitudes, and technologies. This syndrome was broken only by a shift in the paradigms of machinofacture towards the electronic and biological techniques of the post-1970 world. In this new climacteric, opportunities were offered for the development of novel technological sites, which certainly benefited from existing systems of intellectual property rights, but also served to make them less relevant to post-industrial trajectories of growth.

59 At the same time, despite its spread across the globe, the patent system became less important to the key periods and place of technology generation and transfer. Increasingly, transnational corporations and licence agreements, massive investments, and government agencies vied to generate the major technology transfers. For formal statements see THE PRESIDENT'S COMMISSION ON INDUSTRIAL COMPETITIVENESS (1985) *Global Competition: The New Reality*, Washington DC, US Government Printing Office.

Figura 1.- *Occupations of Patentees in Britain 1855, 1860, 1865 and 1870.*