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Disruptive Innovation in the Creative Industries: The adoption of the German horn in Britain 1935-75

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Abstract

This paper examines the interplay between innovation and entrepreneurial processes amongst competing firms in the creative industries. It does so through a case study of the introduction and diffusion into Britain of a brass musical instrument, the wide bore German horn, over a period of some 40 years in the middle of the twentieth century. The narrative contrasts the strategies followed by two brass instrument manufacturers, one a new entrant the other an incumbent. It shows how the new entrant despite a slow start, small scale and a commitment to traditional artisanal skills, was able to develop the technology of the German horn and establish itself as one of the world's leading brands of horn, while the incumbent firm despite being the first to innovate steadily lost ground until like many of the other leading horn makers of the 1930s, it eventually exited the industry.

Keywords: Disruptive innovation, Creative Industries, Musical Instruments

Introduction

For much of the 19th and a substantial part of the 20th century, British orchestras had a distinctive sound. This differentiated them from their counterparts in many parts of Europe and the United States. This sound was the product of the instruments they played, most notably in the horn section of the orchestra. In Britain horn players typically utilized instruments modelled on the Raoux horn from France. This French horn had a narrow bore, a small bell and piston-operated valves. Although more difficult to play and prone to cracked notes, for a hundred years this was the instrument that dominated horn playing in Britain.

However in the interwar years concert-goers in Britain started to experience a different sound. This emanated from foreign orchestras. They generally used the German horn rather than its French counterpart. This instrument used rotary valves instead of piston valves, had a wider bore and a larger flared bell. These features gave the instrument a deeper, richer and louder sound. Although the leading British horn players of the time continued to adhere to the

French version of the instrument, in the mid-1930s one British brass instrument manufacturer boldly stepped forward to produce a German horn.

This innovation ultimately proved to be an example of what Christensen¹ terms a ‘disruptive technology’, a concept that has echoes of earlier innovation studies, notably Schumpeter’s concept of ‘creative destruction’². Disruptive technologies are new technologies that initially underperform with regard to the performance dimensions most valued by mainstream customers of existing products³. However as Schmidt and Druehl⁴ point out these technologies may perform better on other dimensions, especially ones valued by new or fringe customers⁵. These potential customers offer the prospect of new market openings, typically in the form of niche markets⁶. Subsequent development of disruptive technologies may however result in them being more widely applicable. In time their performance may even come to surpass the seemingly superior established technologies⁷. Thus a disruptive technology may eventually come to appeal to the very mainstream customers that initially shunned it. The result is likely to be market disruption, caused by the entry of new firms and the failure of incumbent firms to recognize the threat posed by the new technology⁸, leading to their downfall, and ultimately the exit of some or all of them from the market⁹.

The prediction of market disruption brought on by the introduction of a disruptive technology was played out among the brass instrument manufacturers in Britain from the late 1930s onwards. As a new entrant appeared and developed the new technology, so the incumbent horn makers, despite one of them being the firm that pioneered the manufacture of German horns, were eventually overthrown and exited the industry. The new entrant went on to become one of the world’s leading horn makers.

This paper examines the range of different forces, creative, economic, technological and institutional, that were at work and that ultimately brought about a significant market disruption in brass musical instrument manufacturing. It focuses especially on the interplay between innovations in brass instruments and entrepreneurial activity in new entrant and incumbent firms. The means to do this comes from a case study of innovations surrounding the introduction of the wide bore German horn into Britain in the middle years of the twentieth century. The case contrasts how the incumbent firms focused on their existing customers, especially brass bands and school orchestras, and introduced mass production methods in order to meet their needs, a strategy that led to their eventual exit from the

industry, while a new entrant focused on a different segment of the market, namely professional horn players and by employing traditional artisanal skills, specializing in the manufacture of a single instrument and working closely with its customers, developed a string of innovative new models of horn, that enabled it in time to build a truly international customer base.

The case draws on a combination of interviews with key informants, including former employees, professional musicians and curators of instrument collections, and a range of documentary sources including personal papers and company records drawn from business archives. The former included the personal papers housed in the Bate Collection at Oxford University of the late Reginald Morley-Pegge, a leading authority on the French horn, while the latter included the Boosey and Hawkes archive housed at the Horniman Museum in South London.

The innovation of the wide bore German horn

The interwar years

Until the mid-twentieth century there were significant variations in the styles and sounds of concert orchestras in different countries¹⁰. This was especially true of the horn, where as one leading horn player noted, ‘up to the mid-twentieth century, horn styles were distinctive, and it was relatively easy to detect the nationality of a player’¹¹. This stemmed primarily from differences in the instruments used. Horns with a comparatively narrow bore and Périnet piston valves were almost universal¹² from the mid-nineteenth century onwards in Britain. According to Cousins¹³ even in the 1930s, ‘every one played on the piston-valved French horn in F’. As well as employing piston valves the narrow-bore French horn utilized a smaller bell that gave the bright, clear¹⁴ sound that British brass players and audiences preferred¹⁵. In contrast the German horn, with a wide bore, rotary valves and a larger bell, produced ‘a coarse, thick, open sound’, causing one leading authority on the horn to note, ‘In lightness and brilliance they are inferior to the true French horn’¹⁶. Consequently British orchestras differed in terms of sound from those in much of continental Europe and America¹⁷.

The popularity of the French instrument meant that this was the type of instrument manufactured in Britain throughout the second half of the nineteenth century and much of the first half of the twentieth century. Although the Raoux horn produced in France and used by

among others, Aubrey Brain¹⁸ the principal horn at the BBC Symphony Orchestra from 1928 until 1945, was regarded among British horn players as a ‘most fabled instrument’¹⁹, narrow bore French horns with Périnet piston valves were manufactured by several British firms. During the nineteenth century French horns of this type, certainly orchestral ones used by professional musicians, were produced in small ‘one man’ workshops²⁰ where the exercise of a high level of craftsmanship and skill resulted in the production of a small number of high quality instruments. Examples included Charles Pace of King Street, Westminster and J. Goodison of Soho.

By the early years of the twentieth century French horns of this type were being produced by most of the larger brass instrument manufacturers (see table 1). Of these, the firm of Hawkes & Son was one of the best known for producing high quality instruments. Despite producing a variety of instruments, French horns were a speciality of Hawkes & Son enjoying a separate catalogue in which the company promoted its range of horns (see figure 1). A copy of this catalogue published in 1930 shows that they manufactured two principal models of horn both of which were of the narrow bore French type. The models were the ‘Professional horn’ (H1 model) termed a ‘Raoux’ model and the combined ‘Military & Orchestral horn’ (H2 model). The former was described as ‘of light construction throughout’ and was intended for, ‘the finest and most delicate solo work’²¹. Hawkes & Son’s catalogue claimed the instrument was used by the majority of leading British players of the period including Francis Bradley and Thomas Busby (see figure 2). As well as Hawkes & Son other leading British horn manufacturers included Bessons, Booseys and Rudall, Carte & Co. During the 1930s all produced two models of horn, one for the orchestral market and another more robust model for the military market. The duality evidences the continuing importance of the military market²². Indeed Rudall Carte’s catalogue for 1931 stressed how it made horns for the Royal Military College of Music²³. But for both the military and orchestral markets the instruments produced were piston valved French horns. As Morley-Pegge²⁴ notes these British firms not only copied the Raoux model of French horn, ‘but proudly advertised the fact’ in their catalogues.

As well as these larger concerns at least one smaller one had survived. This was the firm of W. Brown & Sons. Better known as a manufacturer of cornets²⁵, nonetheless the firm enjoyed, ‘a good name for its French horns and supplied some of the most expert players’²⁶.

These included Franz Paersch, first horn at the Hallé Orchestra and Thomas Busby at the London Symphony Orchestra.

The focus on the production of the French version of the horn with piston valves rather than its German counterpart, reflected the prevailing view in Britain where, as Morley-Pegge²⁷ notes, ‘London players had not as yet yielded to the blandishments of the comparatively new German horns’. Leading horn players of the interwar period like Aubrey Brain, clung doggedly to the French narrow bore instrument. They were often able to exert much influence by virtue of the posts they held in particular orchestras and by virtue of teaching posts they held as well. Morley-Pegge notes that Aubrey Brain, ‘would have no truck with the German double horn and insisted that the BBC quartet should only use instruments of the French model’²⁸. He also taught several leading postwar players including his son, Dennis Brain, John Burden and the distinguished soloist Alan Civil. Indeed some, ‘old fashioned players continued to use it well into the 1950s’²⁹.

However during the 1930s things gradually began to change. For the first time the dominance of the narrow bore piston valve French horn in Britain started to face a challenge, as what has been described as a ‘wind of change’³⁰ arose, as some among the classical music community began to question the superiority of the French instrument. Instead they started to see the possibilities offered by the German wide bore horn equipped with rotary rather than piston valves. As Morley-Pegge³¹ notes, ‘musical tastes in Britain suddenly veered from the once so much admired French horn to the no less despised German instrument’.

Three factors lay behind this change. First and foremost was the growth of international travel during the 1930s as concert orchestras increasingly began to tour internationally. This introduced British audiences to many of the great orchestras from abroad including those of Berlin, Budapest, Vienna, Prague and New York³². This not only exposed them to much higher standards of performance but in many cases to new and unfamiliar sounds. An example of this was the Berlin Philharmonic Orchestra’s first performance in London at the Queen’s Hall in December 1927, which introduced a British audience to the ‘bigger and darker sound of German and American orchestras’³³. This stemmed in part at least from their use of the German wide bore horn.

A second factor was the increasing willingness of some conductors and musicians in Britain at this time to experiment and innovate. Such innovations extended to the introduction of new

instruments. Thus Sir Thomas Beecham, conductor of the newly formed London Philharmonic Orchestra (LPO), insisted that the new orchestra's horn section under Charles Gregory should be equipped with wide bore Alexander horns. He even went so far as to send Alan Hyde over to Mainz in Germany in order to acquire a set of Alexander horns,³⁴ paying for the instruments himself. The orchestra's first performance, on 7th October 1932, proved highly successful³⁵, and was received with 'dazzling notices in the newspapers the next day'³⁶. Beecham's pioneering move contrasted with the reaction of leading British horn players, such as Aubrey Brain, who remained adamant that not only he, but the entire horn section of the BBC Symphony Orchestra, the orchestra that according to Pettitt, 'virtually monopolised London's music'³⁷ at this time, should retain the narrow-bore French instrument³⁸.

A third factor leading to increased interest in the German horn was the growing importance of recording sessions for professional musicians and orchestras from the early 1930s onwards³⁹. The introduction of electrical amplification after 1925 both improved the the sound quality of gramophone records and simplified the recording process since microphones were able to capture sound from sources that ranged over a wide area⁴⁰. This, together with a more positive attitude towards the gramophone on the part of musicians from the late 1920s⁴¹ led to orchestras spending an increasing amount of time in the recording studio. A recording contract with EMI played an important in helping Sir Thomas Beecham establish the London Philharmonic Orchestra in 1932⁴². However recordings were still direct on to a wax disc so there was no scope to go back of there was a flaw in the performance⁴³. As a result achieving a more or less flawless performance was very much at a premium in these sessions. This was where the German horn scored over its French counterpart. Described as, 'less capricious than the French horn'⁴⁴, there was usual less need for expensive and time consuming re-takes.

Meanwhile older players continued to resist. Despite this Boosey and Hawkes, the product of a merger in 1930 between the two long established instrument manufacturers Boosey & Co and Hawkes & Son, broke with tradition in Britain when in February 1935 it produced its first German horn. Given the strength of commitment to the French instrument among professional horn players in Britain at this time, this was a bold and innovative step. Just as horn makers in Britain had copied the French Raoux horn, so Boosey and Hawkes appear to have based their new instrument on one made by Ed. Kruspe of Erfurt in Germany. The innovation process was undertaken with the help of professional musicians as a photo (see

figure 3) of the new instrument describes it as the property of the well-known horn player Alan Hyde. With rotary valves, a wide bore and a larger bell this was an important innovation for a country where hitherto only piston valved French horns had been manufactured. Boosey and Hawkes decision to innovate in this way demonstrates the company's awareness of the rising interest in German horns during the 1930s⁴⁵. The development of an British made German horn was to prove a disruptive innovation in time leading to major changes among horn manufacturers.

Despite opposition to this type of instrument from the older established horn players like Aubrey Brain, there proved to be a modest demand for this type of instrument. A total of 38 German horns were produced by Boosey and Hawkes in the five years from 1935. This compares with more than 200 Raoux type horns (see table 4). However the outbreak of war in 1939 quickly brought production to an end. Boosey and Hawkes switched to war production, manufacturing aircraft parts and munitions. Brass instruments continued to be made but in small quantities. Figure 4 shows that facilities for instrument manufacturing at Boosey and Hawkes were cramped and congested during the war years. The few horns manufactured at this time were all piston valved French horns.

The postwar landscape

In the postwar years, horn manufacturing in Britain differed greatly from the 1930s when there had been four well established incumbent horn manufacturers. By the mid-1940s the four firms had been reduced to just one, Boosey & Co acquired all three of its main rivals, including Rudall Carte in 1941 and Besson & Co in 1948. In each case their manufacturing plant was closed and production re-located to the large modern plant built by Hawkes & Son at Deanbrook Road in Edgware. One other smaller firm, noted in the past for its high quality horns used by professional musicians, W. Brown & Sons, although still in business had given up horn manufacturing to focus on repair work. Brass instrument manufacturing at Boosey & Hawkes at its Edgware plant had however been severely disrupted for six years owing to war production.

The ending of hostilities had brought a new source of competition for Britain's remaining horn maker Boosey and Hawkes. This competition came from second hand German horns

made by leading German manufacturers like Alexanders of Mainz and Kruspe of Erfurt. In Germany's war ravaged economy where basic necessities like food and fuel were in very short supply, individuals were often forced to sell their few remaining assets, which included musical instruments. As a result horns, in particular high quality Alexander horns, could be acquired according to one source, for little more than a packet of fags⁴⁶. They were also easy to import in this period - it was not unusual for musicians to travel to Germany with a case carrying a conventional French horn which was then exchanged for a high quality Alexander horn⁴⁷.

Demand for the German designs was also influenced by other post-war developments. In 1945, one of the main bastions of the French instrument, Aubrey Brain, retired through ill-health. Perhaps more importantly, this period saw the de-mobilization of many younger horn players, including Aubrey Brain's son Dennis Brain, John Burden, Tony Tunstall and Ifor James⁴⁸. This younger generation were ready to forsake the French narrow-bore instrument and make the switch to the wide bore German horn, 'thereby closing an era of British horn playing'⁴⁹.

1945 also saw the arrival of a new entrant among the now much depleted ranks of the incumbent British horn makers. During the inter-war years the London-based firm Paxman Bros, originally established in 1919 as a specialist brass instrument dealer⁵⁰, built up a successful repair operation specializing in horns and based in London's musical heartland at Shaftesbury Avenue in Soho (see figure 3). Paxmans had proved themselves to be versatile in this period, and undertook tuning and modification work as a complement to their repair work. This work was well-regarded by professional musicians. For example, in the 1930s, when Sir Thomas Beecham acquired a number of Wagner tubas from Alexanders for use at Covent Garden, it was to Paxmans that he turned to make them playable⁵¹.

The incumbent horn maker

Boosey and Hawkes resumed horn production at their plant in Edgware in 1945, but appear to have made relatively modest changes to their practices in this radically-changed landscape. As in the prewar period they produced both military and orchestral horns. For the military market they continued to produce the same piston valve French horn they had made

previously, a design inherited from Hawkes & Son when the firm was acquired in 1930. Although output of these horns was somewhat erratic with none at all being produced in some years, the overall trend was a slowly declining market. Overall production of 188 horns over the ten years 1945-54 was down on the 1930s level and well down on the 1920s level, and this was the amalgamated output for what had at one time been four independent firms.

The trend for the orchestral sector of the market in contrast was modestly upward from 1945 (see table 6). Initially Boosey and Hawkes only produced piston valve French horns and even these were made in comparatively small numbers. The lack of German horns in the immediate postwar years may have been a reflection on the availability of cheap second hand German horns at this time. However this changed in 1948 when Boosey and Hawkes resumed production of German horns. These were the same models as those produced before the war, though they were now referred to in the company's brass instrument book as, 'rotary horns'⁵². Production of German horns increased steadily. Somewhat surprisingly there appears to have been a continuing demand for the conventional piston valve French horn. As table 6 shows this continued to be produced in quantities not dissimilar from the 1930s, even as late as the mid-1950s. However these horns were now being built in larger batches of up to twelve at a time. German horns in contrast were still being made in small batches of two or four.

What is particularly striking about Boosey and Hawkes's production of horns is how, despite having acquired three additional firms of horn makers, overall production levels for horns remained fairly constant. Over the ten years from 1945-54 production of horns (both orchestral and military) averaged 53.4 per year. This was very similar to the levels of horn production in the 1920s and 1930s (see tables 2 and 3), prior to the consolidation of production at the instrument manufacturing plant in Edgware. This was despite big increases in production of other instruments. The Boosey and Hawkes instrument books show that the firm's output of trumpets and trombones in particular rose sharply in the early 1950s, often with them being produced in much larger batches. Myers⁵³ notes that after 1955 Boosey and Hawks output of brass instruments overall increased very dramatically. Having averaged 3,292 per year in 1945-54, instrument production increased to 22,176 per year in 1950-59, a sevenfold increase. This growth in output from the Edgware plant was the result of an ever increasing range of instruments being made combined with a massive increase in volumes through a switch to mass production. Batch sizes for the more popular instruments like cornets, trumpets and trombones rose to 100 or even 200. Most operations now comprised

repetitive tasks carried out by semi-skilled employees rather than specialist craftsmen who had served a brasswind-making apprenticeship⁵⁴. This allowed the company to increase brasswind production dramatically. This reflected the company's evolution into a volume producer focused on three principal market segments. These were the large brass band market, in which they enjoyed a near monopoly following the acquisition of Besson & Co in 1948⁵⁵, together with the lucrative education market for school bands and orchestras⁵⁶ and a growing export market⁵⁷. In this way Boosey and Hawkes were following a trend set by the larger US manufacturers who produced brass instruments mainly for high school and marching bands.

Orchestral horns in contrast represented only a tiny fraction of Boosey and Hawkes overall output of brass instruments at this time. Indeed horn production remained stuck in something of a backwater. Despite having pioneered the innovation of a German style rotary valve double horn in F and Bb before the war, the company does not appear to have developed this innovation any further. This same horn, referred to in the instrument books as the 'Emperor' model, remained in production throughout the 1950s and 1960s. It was specifically described as a 'rotary horn' and was available in two variants with either corded or lever action. Unlike other instruments these horns continued to be made in small batches of two or four, by the same two individuals, one of whom had made them in the pre-war era. By the 1960s the firm had ceased to actually manufacture rotary valves, with valve clusters now bought in from Alexanders⁵⁸ in Germany.

The outsourcing of valve manufacture proved to be the start of a lengthy process by which Boosey and Hawkes curtailed some of its brass instrument manufacturing activities. Faced with what has been described as a 'mind boggling' span of products in its product range, from the beginning of the 1970s the company increasingly resorted to outsourcing not merely for component and parts but for the production of whole instruments⁵⁹.

When the elder of the two craftsmen specializing in horn production retired in 1970⁶⁰, this presented the company with a dilemma, since by this time horns formed a comparatively small niche in the company's vast range of products. In the face of a demand for increased pay from the one remaining craftsman specializing in the manufacture of horns and reluctant to train up a new craftsman to work alongside him, Boosey and Hawkes decided to outsource not only the manufacture of valves but the production of complete instrument. Henceforth Boosey and Hawkes french horns were built by the Czech instrument maker, Josef Lidl of

Brno⁶¹. Lidl had been making rotary horns since the 1920s⁶² and now produced for Boosey and Hawkes what was essentially a copy of the classic Alexander 103 horn⁶³ dating from about 1950. Described as the 'Model 400' it was sold as a Boosey and Hawkes french horn, though 'Made by Josef Lidl' was clearly inscribed on the bell. Despite being an Alexander design, this model lacked the cache of better known brands of orchestral horn⁶⁴ and was rarely used by professional horn players. Sales continued at the same modest level of between 30 and 50 per year⁶⁵ and this horn remained in production for the next 30 years.

Boosey and Hawkes' decision to outsource the manufacture of their horns in 1970 effectively marked a key turning point in brass instrument manufacturing in Britain general and horn production in particular. The exit from the industry of the fourth and last of the incumbent horn makers at the time of the innovation of German rotary horn in Britain, meant that the market changes brought on by the coming of this disruptive innovation were now complete. The very last chapter closed in 2001 with the decision by Boosey and Hawkes to close the Edgware plant itself⁶⁶, thereby bringing brass instrument manufacturing to an end.

The new entrant.

While it was one of the incumbent horn makers that pioneered the production of the German horn in Britain, it was a new entrant to horn making that developed the innovation. The new entrant was the firm of Paxmans. Founded as Paxman Bros in 1919 by three brothers, Harry, William and Bertram⁶⁷, the firm was originally an instrument dealer based at Southwark Street near London Bridge, supplying instruments to brass and military bands. In 1935 they moved to Shaftesbury Avenue⁶⁸, from where they not only sold instruments but also undertook instrument repairs. Although they briefly produced sousaphones by converting second hand helicons⁶⁹, they gradually began to specialize in horns becoming agents for the Paris-based french horn maker Courtois⁷⁰. They also did a lot of repair work on french horns. The extent to which the firm had begun to specialise in french horns during the 1930s can be gauged from the 1936 edition of the Musicians Union handbook (see figure 5) which carries an advertisement for the firm in the section listing professional horn players.

Having been bombed out during the war, Paxmans acquired spacious new premises at Gerrard Street in Gerrard Street in 1944⁷¹. Here they were well placed to meet the needs of

professional musicians whose services were increasingly in demand in the 1940s. The following year Harry Paxman's son Robert joined the firm. A plumber by training his metal-working skills were to prove invaluable. As well selling brass instruments the firm continued to service and repair them and built up a reputation for adapting and modifying French horns to meet customers' specific requirements⁷².

However with many men and women still in the armed forces and changes arising from wartime production⁷³, there was a shortage of skilled instrument makers. Faced with this Harry Paxman managed to 'poach'⁷⁴ three experienced brass instrument craftsmen, Harry Pace, Charles Staneford and Joe Dobson⁷⁵, from Boosey & Hawkes and Besson & Co.

With five craftsmen now working in the workshop⁷⁶, Harry Paxman, the firm's instrument specialist, was keen not merely to repair and modify French horns but to manufacture them as well, as the scale of the business now matched the workshop-based brass instrument makers that dominated the trade in the late 19th and early 20th centuries⁷⁷. However it wasn't conventional piston valve French horns that Paxman wanted to produce. From the outset, he was determined to innovate by producing the new wide bore German horn that was increasingly being used by horn players in Britain. Rather than design a German horn from scratch Paxman chose to base his horn on ones made by the leading German firm of Alexanders of Mainz.

However innovation presented a number of quite specific technical challenges. The most notable was how to produce the pieces of the instrument that needed to be hand-crafted, like the bell and the valve cluster⁷⁸. The bell required a high degree of craft skill in order to form it from a single sheet of brass⁷⁹. It was a demanding and difficult task requiring, 'skilled tailoring of the sheet-metal' by the instrument maker⁸⁰. It involved the use of a special template in the form of a 'mandrel', which was spun on a lathe. This acted as a jig or former, around which the sheet metal would be hammered to give the bell its precise and distinctive flared shape⁸¹. To acquire this vital piece of equipment Harry Paxman persuaded one of his neighbours who owned a small general engineering business, to 'knock up a mandrel'⁸² of the required shape and size. This proved entirely satisfactory.

The fabrication of the intricate valve clusters was more problematic. Paxman needed to find skilled craftsmen capable of precision machining for the distinctive rotary valves that were

used in horns of German design⁸³. In Germany the smaller horn makers whose scale of production was insufficient to justify the precision machining required could source their valves from third parties, but in Britain this was out of the question since there were no specialist valve manufacturers⁸⁴. However if they were to be manufactured in-house this would potentially involve a significant investment in men and machines to perform the precision machining required. Again Harry Paxman came up with a novel solution to the problem of acquiring this capability. Making use of his personal network of contacts, he found two precision turners who were working for the local gas board. Neither had any prior experience of musical instruments. But they were employed to carry out precision machining of prototype gas fittings and their metalworking skills were transferable, since the tight tolerances needed to produce rotary valve clusters were very similar to those needed for gas fittings⁸⁵. Thus in a classic piece of improvisatory bricolage, Harry Paxman persuaded both men to ‘moonlight’ for Paxmans on Saturdays, while continuing to be employed full-time for the gas board during the week.

The company’s initial output was very limited and in the first year, total production amounted to just three horns⁸⁶. These early horns were still relatively crude but they quickly improved and by 1948 annual production had just crept into double figures⁸⁷. During the course of the 1950s output gradually increased. At this time the company’s range of horns was comparatively limited. They were still basically copies of the German Alexander horn. A Paxman catalogue of from the mid-1950s describes the firm as, ‘specialist makers of Rotary Valve Horns’⁸⁸. The catalogue gives details of three models of horn, all German rotary horns. They including a double horn in F/Bb and a five valve version. Rotary valves were very much one of the firm’s specialisms at this time as a testimonial from Dennis Brain notes the firm’s ‘expert workmanship’ in fitting a rotary valve to one of his horns.

By 1959 the firm’s annual output had reached 30 horns per year⁸⁹, a level that exceeded Boosey’s output of orchestral horns in the 1920s (see table 2). Horn production was now in the hands of three craftsmen, each of whom specialised in a particular aspect of horn production. Robert Paxman made bells while Fred Leach was ‘the valve man’⁹⁰. Fred had perfected the machining and turning of rotary valves and now crafted very high quality valve blocks. The third person was Ted Adams, the horn builder. Unlike the others, he was himself a horn player, which meant that as well as being, ‘a really good craftsman’, he was someone who, ‘really cared about making beautiful horns’⁹¹. This small close-knit team of craftsmen,

each of whom contributed in a different way, was to form the cornerstone of Paxmans' horn manufacturing capability over more than thirty years.

The 1960s saw Paxman enter a new phase in their development. The previous year they had modified a horn for an Australian horn player resident in Britain. Richard Merewether (see figure 6) was a talented professional horn player with distinguished musical connections in the orchestral field. He had studied at the Sydney Conservatorium of Music, where his circle of friends included the conductor Charles Mackerras, the violinist, Patricia Tuckwell and her brother, Barry Tuckwell⁹², who was later to become a horn player of international renown. Merewether had followed Mackerras and Tuckwell to Britain in 1950. By the late 1950s he was working as a freelance horn player who, 'made something of a specialisation of very, very high register parts'⁹³. To facilitate this Merewether had persuaded Alexander's of Mainz to build him a horn to his own design specifically for his own personal use. When in 1959 he wanted further modifications, rather than make the trip to Mainz, Merewether got Paxmans to carry out the work⁹⁴. The following year he came back with a new design of double descant horn in F/F-Alto and having learnt that Paxmans possessed the capacity to manufacture rotary valves in-house, he asked them to build it. This particular instrument, built solely for Merewether's own personal use proved extremely successful. So successful was it, that gradually the word 'got around'⁹⁵ amongst professional horn players about the playing capabilities of this Merewether design, Paxman-manufactured horn. At this time according to one leading horn player, 'all descant horns that were made before Merewether came along did have flaws'⁹⁶. Among other weaknesses, 'they were difficult to play' and 'they were fairly out of tune'.

Paxmans duly began to build Merewether's design for a double descant horn in F/F-Alto horn and offer it for sale to professional musicians. This was followed by a similar instrument in Bb//F-Alto⁹⁷. As a result the Paxman range of horns gradually began to expand. A catalogue⁹⁸ for the firm from mid-1960s shows the product range having expanded to include some 12 models of horn, all German-style rotary horns. They include two full double horns in F/Bb, three compensating double horns in F/Bb, five single horns and two dual bore F/F-Alto double horns. A feature of all the horns was the use of hollow rotors for the valves, a feature which the catalogue notes were, 'used by the finest German makers before the War, but now abandoned by them'⁹⁹. The catalogue describes the horns as, 'Paxman RM horns', reflecting the close collaboration between Paxman staff and designer Richard Merewether.

As the design partnership between Merewether and Paxman flourished, a succession of new models followed. In 1967 Paxmans introduced a full triple horn in F/Bb/F alto, comprising three full sections of tubing. In 1968 a Merewether design double horn in Bb-Alto/Bb soprano appeared, enabling the modern horn player to cope with Baroque horn parts. Larkin¹⁰⁰ notes that a feature of this instrument was, ‘a new control valve in which the windway diverges close to the mouthpiece before converging in a chamber with a larger tube diameter at the point where the tubing begins to expand into the bell’.

In 1971 Merewether was forced by ill health to retire from horn playing. This provided him with an opportunity to work for Paxmans full time. This gave added impetus to the Merewether/Paxman partnership with the decade of the 1970s regarded by many as its heyday. Paxmans continued to innovate by producing new horn models. A Paxman catalogue for 1975¹⁰¹ reveals the product range had expanded dramatically with no less than 36 different models of horn now available. To their range what were described as ‘virtuoso’ horns featuring single, full double and compensating double horns were now added a variety of ‘dual bore double descant horns’, ‘dual bore triple descant horns’ and ‘dual bore compensating triple descant horns’. With this extensive range of specially designed horns Paxmans were able to meet the varied needs of professional horn players. And the company was now producing more than 200 professional quality hand-built horns per year¹⁰². There was no longer sufficient space in the London workshop that formed part of the showroom. In 1972 the showroom relocated to Gerrard Street in Covent Garden in the heart of the West End. This move prompted the search for additional workshop premises. Since both Fred Leach and Ted Adams lived in Kent¹⁰³, they suggested moving the production side of the business out of the capital to somewhere where appropriate industrial premises were available and rents were lower. A small factory unit was acquired on an industrial estate at Marden, near Maidstone. With greater space additional staff could be taken on, bringing the total employed in the workshop producing horns to eight¹⁰⁴. This growth presented new problems, in particular around sub-contracting of production activities. Robert Paxman was seen by colleagues as particularly astute in distinguishing, ‘which stuff you do in-house and which stuff you outsource so that your time is used effectively’¹⁰⁵. In practice, a large proportion of the work was retained in-house. From a company perspective, retaining control of production enabled the company to build horns of the highest quality, and horns produced at this time are looked back on as being, ‘Really good quality, an almost totally British made horn ... [built by] people who were really proud of their work’¹⁰⁶.

During the course of the 1970s the innovative features and quality of workmanship of Paxmans' horns became more widely acknowledged by professional musicians:

‘The word got about that Paxmans were making horns that were on a par with the German instruments and various London orchestras including the London Symphony Orchestra and the Royal Philharmonic ... were seen and heard to be playing Paxman horns’¹⁰⁷

The company was now recognised as a manufacturer of ‘excellent instruments’¹⁰⁸. Its international reputation was also growing rapidly. At the start of the 1970s, Paxman horns were virtually unknown in other major markets¹⁰⁹, but under sales manager Willi Watson, Paxmans began to target not merely leading horn players in Britain but those from other countries. One of their early successes came in 1975 when the German horn virtuoso Herman Baumann acquired a Paxman triple horn (see figure 6). Other internationally recognized horn players followed. The triple horn proved a particular success in the United States, helping to establish the company’s reputation in North America for horns of the highest quality. Osmun Music, based in Amherst, Massachusetts first became agents for Paxman horns in 1978¹¹⁰.

By the early 1980s, in Richard Merewether’s own account, the company had, ‘built it up and up until most countries in the world now have a lot of our horns played by their leading players’¹¹¹. Sadly the Merewether-Paxman design partnership came to an abrupt end with the death of Richard Merewether in 1985. By that time their collaboration had produced some 50 models, though this figure included many derivatives. However, this did not bring an end to innovation at Paxmans. One of the later developments, which Robert Paxman oversaw shortly before his own retirement in 1995, was the introduction of lightweight valves fitted with titanium rotors. By then, forty years of research and development had produced a range of instruments that put Paxman Bros at the forefront of the manufacture of French horns of the highest quality.

Discussion and Conclusion

When the wide bore German horn first appeared in Britain there were four incumbent brass instrument makers producing French horns. Of these the leading firm in the orchestral market

was Hawkes & Son. Certainly its horns were used by the leading professional horn players of the day like Francis Bradley. By the time the wide bore German horn with rotary valves had really begun to make an impact in the early 1950s, the four had already been reduced to one. Boosey and Hawkes replicated the same recipes it had learned in the pre-war market, namely focusing on the big market segments like brass bands and school orchestras and an emphasis on cost reduction through the implementation of mass production. As a result they failed to build on their pioneering innovation of 1935. The same German horn first introduced in the 1930s continued in production in the 1950s and 1960s. Boosey and Hawkes failed to develop and extend their capabilities in design and manufacturing. Instead they outsourced the key technology of rotary valve manufacture in the 1960s. This led ultimately to outsourcing the production of the complete instrument in the early 1970s. The result was a lack of new models and a lack of innovation. This meant they failed to meet the needs of what had at one time been a modest market niche but one that grew substantially in the postwar era.

This was a classic example of Christensen's¹¹² disruptive innovation, where the introduction of a new technology leads to market disruption and the exit of some or all of the incumbent firms, largely because they continue to focus on the needs of their existing customers, ignoring customers on the fringe. In this case the existing customers were brass bands and school orchestras while the fringe customers were professional musicians playing in classical orchestras. It was left to a new entrant to meet the needs of this latter group through innovations that produced a new horns of the highest quality that were better able to meet their needs.

Just how the new entrant provides some valuable lessons in business development. Unlike the incumbents they specialized in a single instrument. Over a number of years they developed a range of craft skills, particularly in the field of valve machining and bell making that gave them valuable capabilities and a competitive advantage in producing high quality instruments. Perhaps most important of all however was their ability to combine horn design and manufacturing skills. This was an almost unique combination that enabled the firm to produce a steady succession of innovations that not only met the needs of an expanding community of professional horn players, but gave the firm an international reputation in the process thereby creating an internationally recognized brand¹¹³.

Perhaps surprisingly this is not an unusual pattern for the creative industries. During the course of the last 40 years a number of new entrants have emerged in musical instrument

manufacturing. A number of these are in the brass instrument field. They include several firms established by former employees of existing instrument makers. Notable examples in Britain are Rath Trombones and Smith-Watkins Trumpets. In both cases these are firms that specialize in a single instrument, producing very high quality markets aimed at professional musicians. Nor is this a purely British phenomenon. In Italy Paolo Fazioli set out in 1980 to design a piano that would sound superior to any other piano¹¹⁴. Like Paxmans, Fazioli relies on craft skills and design expertise. Producing only 140 instruments a year his hand-made products embody ‘true craftsmanship’¹¹⁵ and are firmly aimed at the top niche in the market rivalling the legendary Steinway brand.

Acknowledgement

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The Morley-Pegge papers, Bate Collection, Oxford University

Table 1
Larger Brass Manufacturers circa 1900

Date	Firm	Location	Employees	Output (weekly)
1890	F.Besson & Co.	Euston Road, London	131	100
1895	Hawkes & Son	Denman St, Piccadily Circus, London	100	n/a
1890	Boosey & Co.	Stanhope Place, Marble Arch, London	100	n/a
1892	J Higham	Manchester	70-90	n/a
1889	Salvation Army	St Albans	n/a	16

Source: Myers (1991: p185)

Table 2
Boosey & Co: horn production 1920-29

Model	Military horn	Orchestral horn	Total
Year	A41 (Eb)	A40 (Eb)	
1920	12	27	39
1921	46	25	71
1922	39	11	50
1923	42	19	61
1924	0	36 ^a	36
1925	49	16	65
1926	30	0	30
1927	30	16	46
1928	36	10	46
1929	24	15	39
Total	308	175	483

Source: Boosey and Hawkes archive,

^a includes 6 model 42 (F & Eb) horns

Source: Boosey & Hawkes archive, A227

Table 3
Boosey & Co: horn production 1930-39

Model	Military horn	Orchestral/ Professional horn	Total
Year	<i>A41/ H&S No.2</i>	<i>A40/ H&S No.1</i>	
1930	30	8	38
1931	24	8	32
1932	6	2	8
1933 ^a	11	9	20
1934 ^b	62	15	77
1935	22	77 ^c	99
1936	31	59	90
1937	28	35	63
1938	13	49	62
1939	12	27	39
Total	239	289	528

Source: Boosey and Hawkes archive,

^a 1933 Boosey & Co's *A40 Orchestral horn* is replaced by Hawkes & Son's *Professional Raoux model* (designated No.H1 model).

^b 1934 Boosey & Co's *A41 military horn* begins to be replaced by Hawkes & Son's *Military and orchestral No.H2 model* now designated B4047.

^c this includes 44 horns styled as 'German horns'.

Table 4
Boosey & Hawkes production of orchestral horns 1935-39

Year	French horn	German horn	Total
1935	59	18	77
1936	42	17	59
1937	32	3	35
1938	49	0	49
1939	27	0	27
Total	209	38	247

Source: Boosey and Hawkes archive,

Table 5
Mergers of Brass Instrument Makers

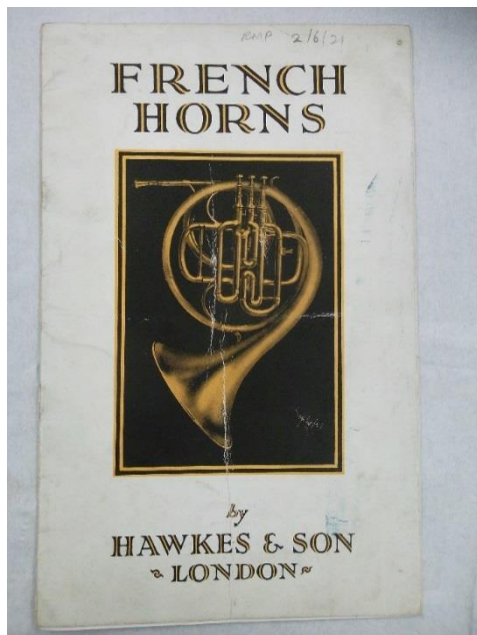
Date	Acquirer	Acquired	Products	Changes in activity
1917	Boosey & Co.	J R Lafleur & Son	Manufacturer & importer	n/a
1925	F. Besson & Co.	Quilter	Not known	n/a
1930	Boosey & Co.	Hawkes & Son	Brass manufacturer	Marble Arch plant closed & transferred to Edgware
1930	Mayers & Harrison	J Higham	Brass Manufacturer	Plant closed/ production ceased
1940	F. Besson & Co.	Wheatstone & Co	Instrument manufacturer	Manufacturing transferred
1941	Boosey & Hawkes Ltd	Rudall Carte & Co	Flute & Brass manufacturer	Plant closed 1939 & production transferred to Edgware
1948	Boosey & Hawkes Ltd	F. Besson & Co	Brass manufacturer	Plant closed & production transferred to Edgware
1970	Boosey & Hawkes Ltd	Salvation Army Brass factory	Brass manufacturer	Plant closed & production transferred to Edgware

Table 6
Boosey & Hawkes production of orchestral horns 1945-54

Tear	French horn	German horn	Total
1945	15	0	15
1946	4	0	4
1947	28	0	28
1948	3	18	21
1949	18	18	36
1950	17	30	47
1951	39	18	57
1952	19	8	27
1953	18	34	52
1954	30	29	59
Total	191	155	346

Source: Boosey and Hawkes archive,

Figure 1
French horn catalogue of Hawkes & Son, circa. 1930



Source: Morley-Pegge papers, RMP 2/6/21

Figure 2 British horn players of the 1920s



Source: Morley-Pegge papers, RMP 2/6/21

Figure 3
Boosey & Hawkes German horn circa 1935 (horn on the left)



Boosey & Hawkes archive, DSCO 3472, p95

Figure 4
Boosey & Hawkes brass instrument production during World War Two



Source: Boosey & Hawkes archive

Figure 5
Advertisement in Musicians Union handbook, 1936.

FRENCH HORN

**Members are Forbidden to Employ or Offer Engagements
to Non-Union Musicians**

Barnes, A. P., 42 De Vere Gdns, Hford, Essex. (Tele.: Valentine 2093.)
Barrow, R. H., 3 Aberdeen Ave., Toronto, Canada.
Basten, Robt.
Bradley, E., "Brierley," Preston Rd., Nr. Harrow. (Tele.: Arnold 4073.)

PAXMAN BROS. LTD.
158 SHAFTESBURY AVENUE, W.C.
First Class Repairs
Phone: Temple Bar 1005

FRENCH HORN (Continued)

Bradley, F., 13 Eversley Ave., Wembley Park, Mdx. (Tele.: Arnold 4015.)
Brain, Aubrey H., 22 Richmond Park Rd., East Sheen, S.W.14. (Tele.: Prospect 4098.)
Brightmore, C. V., Lauriston, Hawks Hill Close, Leatherhead, Surrey. (Tele.: Leatherhead 28.)
Brown, G. A. (and Wife), 73 Parkholme Rd., Dalston, E.3.
Bryant, R. E., 49 Henway Rd., S.W.5. (Tele.: Paxman 3171.)
Buck, J. W., 98 Mayson Rd., Charlton, S.E.7. (Tele.: Woolwich 1523.)
Burditt, F., 57 Abercorn Rd., S.W.16. (Tele.: Pollards 4912.)
Burditt, W. D., 37 Abercorn Rd., S.W.18. (Tele.: Pollards 4912.)
Burrows, V. S., 114 Saxe Road, Ponders End, Mdx. (Tele.: Enfield 1881.)
Button, E. A., 57 Rayleigh Rd., Wimbledon, S.W.19. (Tele.: Liberty 4591.)

Source: Musicians' Union (1936)

Figure 6
1st International Brass Congress at Montreux, 1976
Willi Watson, Richard Merewether, Herman Baumann and Robert Paxman (left to right)



Source: Willi Watson – personal communication

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- ¹ Christensen, *The Innovator's Dilemma*, xv.
- ² Yu and Hang, 'A Reflective Review of Disruptive Innovation Theory', 436
- ³ Schmidt and Druehl, 'When Is a Disruptive Innovation Disruptive?' 347.
- ⁴ *Ibid*, 347,
- ⁵ Christensen, *The Innovator's Dilemma*, xv.
- ⁶ Yu and Hang, 'A Reflective Review of Disruptive Innovation Theory'.
- ⁷ Markides, 'Disruptive Innovation: In Need of a Better Theory?' 19.
- ⁸ Christensen and Raynor, *The Innovator's Solution*.
- ⁹ Bower and Christensen, 'Disruptive Technologies: Catching the Wave'
- ¹⁰ Tuckwell, *Horn*, 142.
- ¹¹ *Ibid*, 143.
- ¹² Montagu, *Horns and Trumpets of the World*, 138
- ¹³ Cousins, *On Playing the Horn*, 60.
- ¹⁴ Brain, 'The German Horn: A Comparison', 195.
- ¹⁵ Horniman Museum, *Winds of Change* exhibition
- ¹⁶ Forsyth, *Orchestration*.
- ¹⁷ Horniman Museum, *Winds of Change* exhibition
- ¹⁸ Pettitt, *Dennis Brain: A biography*, 49.
- ¹⁹ Wyse, 'Test your strength'.
- ²⁰ Morley-Pegge papers, RMP2/6/21, Bate collection, Oxford University.
- ²¹ Morley-Pegge papers, RMP2/6/21, Bate collection, Oxford University.
- ²² Interview with Bradley Strauchen-Scherer, 5th October 2015.
- ²³ Bate collection, Morley-Pegge papers, RMP 2/6/21, Bate collection, Oxford University.
- ²⁴ Morley-Pegge, *The French Horn*, 43.
- ²⁵ Rose, *Talks with Bandsmen*, xxx
- ²⁶ Humphries, W. Brown & Sons, 3
- ²⁷ Morley-Pegge, *The French Horn*, 51.
- ²⁸ Morley-Pegge, *The French Horn*, 169.
- ²⁹ Montagu, *Horns and Trumpets of the World*, 138.
- ³⁰ Whyse ??? The Guardian??
- ³¹ Morley-Pegge, *The French Horn*, 43.
- ³² Day, *A Century of Recorded Music*, 88.
- ³³ Horniman Museum, *Winds of Change* exhibition.
- ³⁴ Montagu, *Horns and Trumpets of the World*, 138.
- ³⁵ Lucas, *Thomas Beecham*, 210.
- ³⁶ Reid, *Thomas Beecham*, 204
- ³⁷ Pettitt, *Dennis Brain: A biography*, 48.
- ³⁸ *Ibid*, 49.
- ³⁹ Interview with Jeremy Montagu, 11th September 2015
- ⁴⁰ Day, *A Century of Recorded Music*, 16
- ⁴¹ *Ibid*, 78
- ⁴² Lucas, *Thomas Beecham*, 209.
- ⁴³ Interview with Jeremy Montagu, 11th September 2015.
- ⁴⁴ Lucas, *Thomas Beecham*, 210.
- ⁴⁵ Interview with Bradley Strauchen-Scherer, 5th October 2015.
- ⁴⁶ Interview with Jeremy Montagu, 11th September 2015.
- ⁴⁷ Interview with Jeremy Montagu, 11th September 2015.
- ⁴⁸ Kampen, 'Ifor James'.

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- ⁴⁹ Gamble and Lynch, *Dennis Brain*, 190.
- ⁵⁰ Mathez, 'Paxman Bros Ltd', 72.
- ⁵¹ Interview with Jeremy Montagu, 11th September 2015.
- ⁵² Instrument book A227/062, Boosey and Hawkes archive.
- ⁵³ Myers, 'Brasswind Manufacturing at Boosey & Hawkes', 61.
- ⁵⁴ *Ibid*, 61.
- ⁵⁵ *Ibid*, 58.
- ⁵⁶ Myers, 'Design, Technology and Manufacture after 1800', 117.
- ⁵⁷ Myers, 'Brasswind Manufacturing at Boosey & Hawkes', 61.
- ⁵⁸ Interview with Jeffery Emerson, 23rd May 2016.
- ⁵⁹ Wyse, 'Test your strength'.
- ⁶⁰ *Ibid*.
- ⁶¹ *Ibid*.
- ⁶² Rees, *I Found My Horn*, 133.
- ⁶³ Information provided by Tom Fisher.
- ⁶⁴ Rees, *I Found My Horn*, 105.
- ⁶⁵ Interview with Jeffery Emerson, 23rd May 2016.
- ⁶⁶ Wyse, 'test your strength'.
- ⁶⁷ Mathez, 'Paxman Bros Ltd', 72.
- ⁶⁸ *Ibid*, 75.
- ⁶⁹ Smith and Blundel, 'Improvisation and bricolage versus rationalisation'.
- ⁷⁰ Interview with Robert Paxman, 12th February 2010.
- ⁷¹ Larkin, 'Paxman', 40.
- ⁷² Gamble and Lynch, *Dennis Brain: A Life in Music*, 191.
- ⁷³ For example, artisanal small boat-building was largely displaced by new manufacturing techniques in the postwar period, a product of skills shortages combined with restricted access to traditional materials, Blundel, *Little Ships*, 318-320
- ⁷⁴ Interview with Robert Paxman, 12th February 2010
- ⁷⁵ Mathez, *PAXMAN Bros Ltd*, 74
- ⁷⁶ At the turn of the century the noted cornet maker William Brown employed a staff of five in his workshop in Kennington. Rose, *Talks with Bandsmen*, 189
- ⁷⁷ De Keyser, 'The Paradigm of Industrial Thinking', 233
- ⁷⁸ Merewether, *The Horn, The Horn*, 17
- ⁷⁹ Barclay, *Design, Technology and Manufacture*, 32.
- ⁸⁰ Merewether, *The Horn, The Horn*, 17.
- ⁸¹ Barclay, *Design, Technology and Manufacture*, 34.
- ⁸² Interview with Robert Paxman, 12th February 2010.
- ⁸³ Horns produced in Britain and France used conventional piston valves but a particular feature of German horns was that they used larger bore rotary valves. Rotary valves had been patented by Josef Reidl in the mid-19th century. To create them, entry and exit ports are brazed into an outer casing, within which an inner rotor rotates to direct the passage of air. It is critical to obtain an airtight seal, with clearances between rotor and casing of no more than 0.025mm all round. Hence the rotor, which was machined from a solid bar on the early Paxman horns, had to be precision machined to very fine tolerances. Merewether, *The Horn, The Horn*, 19.
- ⁸⁴ Boosey & Hawkes for example had the capacity to manufacture their own valves.
Horniman Archive.
- ⁸⁵ Interview with Jeremy Montagu, 11th September 2015.
- ⁸⁶ Mathez, 'Paxman Bros Ltd', 75.
- ⁸⁷ Interview with Luke Woodhead, 21st July 2010.

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- ⁸⁸ Morley-Pegge papers, RMP 2/6/22.
- ⁸⁹ Mathez, 'Paxman Bros Ltd', 76
- ⁹⁰ Interview with Luke Woodhead, 21st July 2010.
- ⁹¹ Interview with Luke Woodhead, 21st July 2010.
- ⁹² It was Merewether who gave Barry Tuckwell his first lesson on the horn. Phelan, *Charles Mackerras: A Musician's Musician*, 40.
- ⁹³ Interview with Michael Thompson, 16th June 2010.
- ⁹⁴ Mathez, *PAXMAN Bros, Ltd* 76.
- ⁹⁵ Watson, 'An Interview with Richard Merewether', 88
- ⁹⁶ Interview with Tony Halstead, 29th May 2010.
- ⁹⁷ Larkin, 'Paxman', 40.
- ⁹⁸ Morley-Pegge papers, RMP 2/6/5a.
- ⁹⁹ *Ibid.*.
- ¹⁰⁰ Larkin, 'Paxman', 40.
- ¹⁰¹ Morley-Pegge papers, RMP 2/6/24, Bate collection, Oxford University.
- ¹⁰² Watson, 'An interview with Richard Merewether', 88.
- ¹⁰³ Interview with Luke Woodhead, 21st July 2010.
- ¹⁰⁴ *Ibid.*
- ¹⁰⁵ *Ibid.*
- ¹⁰⁶ *Ibid.*
- ¹⁰⁷ Interview with Tony Halstead, 29th May 2010.
- ¹⁰⁸ *Ibid.*
- ¹⁰⁹ The specialist instrument dealer Bob Osman has recalled that, 'I first became aware of Paxman around 1970, when they were virtually unknown in the United States.' Osman Music Inc [\[website\]](#) 2012.
- ¹¹⁰ Interview with Bob Osmun, October 2015.
- ¹¹¹ Watson, 'An Interview with Richard Merewether', 88
- ¹¹² Christensen, *The Innovator's Dilemma*.
- ¹¹³ Hembd, 'Thoughts on 'Quality'.
- ¹¹⁴ The Economist, 'Piano nobile', 76.
- ¹¹⁵ Rusbridger, *Alan, Play It Again*, 337.