CHAPTER 4

E.T. BELLHOUSE AND CO.

ENGINEERS AND IRON FOUNDERS

Edward Taylor Bellhouse (1816 – 1881), eldest son of David Bellhouse junior (1792 – 1866), was one of the leading engineers in Manchester during the nineteenth century.[1] He began work as an apprentice to Messrs. Wren and Bennett beginning in about 1830. This firm was one of the leading millwright-engineering concerns in Manchester, especially in the area of cotton factories. After six and a half years with Wren and Bennett, Edward Bellhouse worked for a year as a journeyman millwright at the Coloa Mills and at the St. Helens' Union Plate Glass Works. Another year was spent at Sir William Fairbairn's works in the Isle of Dogs, Millwall. His last year as an employee was spent working for the Liverpool Grand Junction Railway. Bellhouse's grandfather intended that Edward take over the foundry. His education has every appearance of having been planned by his father, using the father's connections with Fairbairn and the glass company, for example.

The Bellhouses seem to have had a continuing professional relationship with William Fairbairn. In 1832, David Bellhouse and Son built the cabin and deck for the iron canal packet boat "The Lancashire Witch constructed by Fairbairn and Lillie.[2] David Bellhouse junior and Fairbairn jointly reported on the fall of the mill at Oldham in 1845.[3] That same year David Bellhouse and Fairbairn were corresponding about the loading of cast iron beams.[4] In 1854, when Edward Bellhouse constructed a prefabricated iron customhouse for the town of Payta in Peru, Fairbairn visited the building while it was on display in Manchester.[5] Curiously, Edward Bellhouse made no reference to his family's professional connections with Fairbairn when Bellhouse read a paper, entitled "On Pole's Life of the Late Sir William Fairbairn," to the Manchester Association of Employer, Foremen and Draughtsmen in 1878.[6]

The intentions of the grandfather were fulfilled on July 1, 1842, when the firm of E.T. Bellhouse and Co. commenced operations at the Eagle Foundry in Hunt (now Whitworth) Street by the Rochdale Canal off Oxford Road. The location of the foundry may be seen on an 1886

insurance map of Manchester. The "saw mills" at the left of the map are on the site of David Bellhouse senior's timber yard that became John and William Bellhouse Ltd.

Part of Goad's 1886 insurance map of Manchester[7]

E.T. Bellhouse and Co. was originally formed as a partnership between father and son.[8] The partnership, with the father as an increasingly silent partner, probably continued until the father's death in 1866. In the early years David Bellhouse junior actively promoted his son's business. In the 1845 contract obtained by the father to build the Manchester South Junction Railway, Edward Bellhouse was responsible for constructing nine cast-iron bridges that spanned the canals and rivers along the route. While work was proceeding on these bridges in 1847, another bridge, Robert Stephenson's Trussed Iron Girder Bridge at Chester, collapsed as a train was passing over it. Since the South Junction bridges were patterned after this bridge, work was stopped and segmental arched bridges were substituted for the original ones.[9] These new bridges were described as ones of "very superior workmanship."[10]

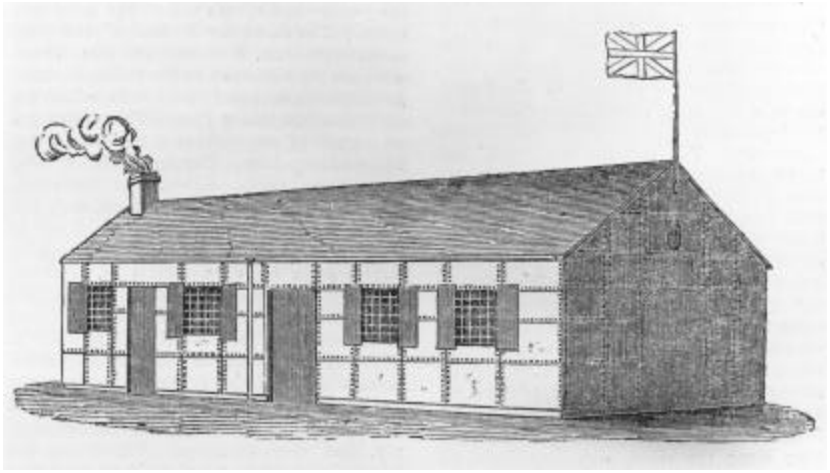
Very quickly Edward Taylor Bellhouse expanded the scope of his business. By the late 1840s he was manufacturing prefabricated iron buildings, the work he is most famous for today. Buildings constructed of iron first date in England from about 1790.[11] The earliest examples

from this date are iron lock keeper's cottages built of iron slabs or cast iron. A major development in this area of interest to Edward Bellhouse's career occurred in 1829 when H.R. Palmer, a London civil engineer, introduced corrugated iron roofing. In an 1821 advertisement, Richard Walker illustrated an open-ended warehouse with a barrel-vaulted roof of curved corrugated iron sheets. The sheets were riveted together and had tie rods for lateral stability. This type of roof was used at Walker's own factory in Bermondsey and several sheds at London Docks. It was also used at the Coal Depot of the London Gas Works at Vauxhall in about 1837. In 1840, at the time Bellhouse was working for him, William Fairbairn erected his Turkish Corn Mill at his Millwall works, the first three-story factory building all of iron construction. The roof was the same type used by Walker. A second major development was the idea of portable corrugated iron buildings. These were introduced, again by Richard Walker, for export to Australia. Work in this area continued by others into the 1840s. Out of these developments, Edward Taylor Bellhouse emerged as a leading manufacturer of prefabricated iron buildings.[12]

Bellhouse's own work in iron buildings was probably influenced by construction of the Turkish Corn Mill during the time Bellhouse worked at Millwall for Fairbairn. A small number of Bellhouse's early iron buildings use the barrel-vaulted corrugated iron roof. While Fairbairn may have been the inspiration, it was the California Gold Rush of 1849 that gave impetus to Bellhouse's work. After gold was discovered at Colona, El Dorado, California in January of 1848, tens of thousands of men from all over the world poured into California to pan for gold, thus creating an acute housing shortage. In May of 1849, E.T. Bellhouse and Co. was the first European manufacturer to take advantage of the demand. At that time, Bellhouse constructed a 60 × 24-foot warehouse in Liverpool in a mere two weeks "for Messrs. Pim and Roberts who were proceeding to San Francisco." The walls of the warehouse were of wrought-iron plates 1/8 inch thick and were bolted to an iron frame. The doors and shutters were also of wrought iron while the window sashes, ventilators, skylights and gutters were of cast iron. The building was constructed such that it could be taken down and packed for shipping. Each piece was marked so that it could be assembled at its destination. A second warehouse, this one 40 × 20 feet, was also constructed for the California market at this time.[13]

Subsequently Bellhouse sent out many prefabricated iron buildings to California. Over the years 1849 and 1850 he appears to be the major supplier of this commodity.[14] His buildings included two-story houses for the more well to do, warehouses and hundreds of cottages for the

average prospector. The two-story houses were priced in the range of £450 to £500. One of those built in the latter part of 1849 had four rooms per story and was described as "equal to that of the most comfortable house of equal size" in England.[15] The cottages cost less than £100. They were much smaller with two rooms only, a dayroom and a bedroom.[16] There were features, other than size, that made the two-story houses more expensive. In the two-story houses, the iron was covered with a coating of a tin alloy to prevent rust; the cottages were made of wrought iron only. The mouldings on the larger houses were more ornamental than on the cottages and the door fixtures were of brass rather than iron. It was thought that the tinned iron houses, which were the colour of frosted silver, would be advantages in the California climate. The sun's rays would be reflected from the surface of the house so that the material would absorb less heat.[17]



1849 Warehouse for San Francisco[18]

There is a certain evolution in Bellhouse's buildings for the California Gold Rush. In the early buildings, the walls were made of wrought iron plates. Some of the early cottages had barrel-vaulted roofs following Walker and Fairbairn. Later in 1849 and definitely by early 1850, the walls had changed to corrugated iron to increase their strength. The corrugations ran vertically. Pitched roofs supplanted the barrel-vaulted roofs.[19] Bellhouse even experimented with the pitched roofs. A twelve-room lodging house built in 1850 for the Gold Rush had a pitched roof with each slope concave in shape. This gave the building an eastern appearance.[20]

Although iron houses continued to sell in San Francisco for as much as ten times their cost as late as October of 1850, the California boom for Bellhouse came to an end shortly there-

after. Over the winter of 1849-50, local lumbering got underway, and brickyards and quarries were developed, all of which brought down the price of building materials. By the end of 1850 the boom was over. Cargoes, including houses, were being put up for auction for freight charges only. There were two other factors that slowed sales. Contrary to expectations, the buildings were too hot in the California sun. Also, they were not fireproof. In the San Francisco fire of 1851 iron buildings, when exposed to serious fire, melted and curled up.[21]

There was another gold rush, this one to Australia following the discovery of gold there in 1851. Bellhouse also tried to take advantage of the new market by exporting prefabricated houses and warehouses, mainly to the Melbourne area of Australia. Two of his warehouses survived until the 1960s. A gable-roofed cottage, which stood in the Melbourne suburb of Fitzroy, survives and has been taken over by the National Trust of Australia. The cottage, which has a single door and a window at each end, measures 12 × 24 feet. It now stands in the Portable Houses Museum in South Melbourne.[22]

Prior to the California Gold Rush, Bellhouse probably had little or no involvement in the building of iron houses. The entries of E.T. Bellhouse and Co. in the Manchester directories make no mention of this activity. Bellhouse's professions, as given in the directories, were engineer, millwright, iron founder and hydraulic and screw press manufacturer. The first mention of iron buildings was in the 1854-5 directory when Bellhouse placed a full-page advertisement describing his activities. An iron church in Jamaica has been attributed to Bellhouse, but this was actually the work of another, Peter Thompson.[23]

Once he was in the business of making iron buildings, Edward Bellhouse tried to diversify the sources of his demand. During the Gold Rush, in September of 1849, Bellhouse was making domestic and agricultural outbuildings of iron for the domestic market.[24] The buildings were made for tenants who did not want to build permanent and substantial buildings that would become part of the freehold. When the tenant left the land, the buildings could be disassembled and taken with him. Later Bellhouse constructed iron cottages for emigrants. Presumably, an emigrant could take his house with him as he left for the colonies. A model of an emigrant's cottage was shown as the Great Exhibition of 1851 held in London at the Crystal Palace.[25]

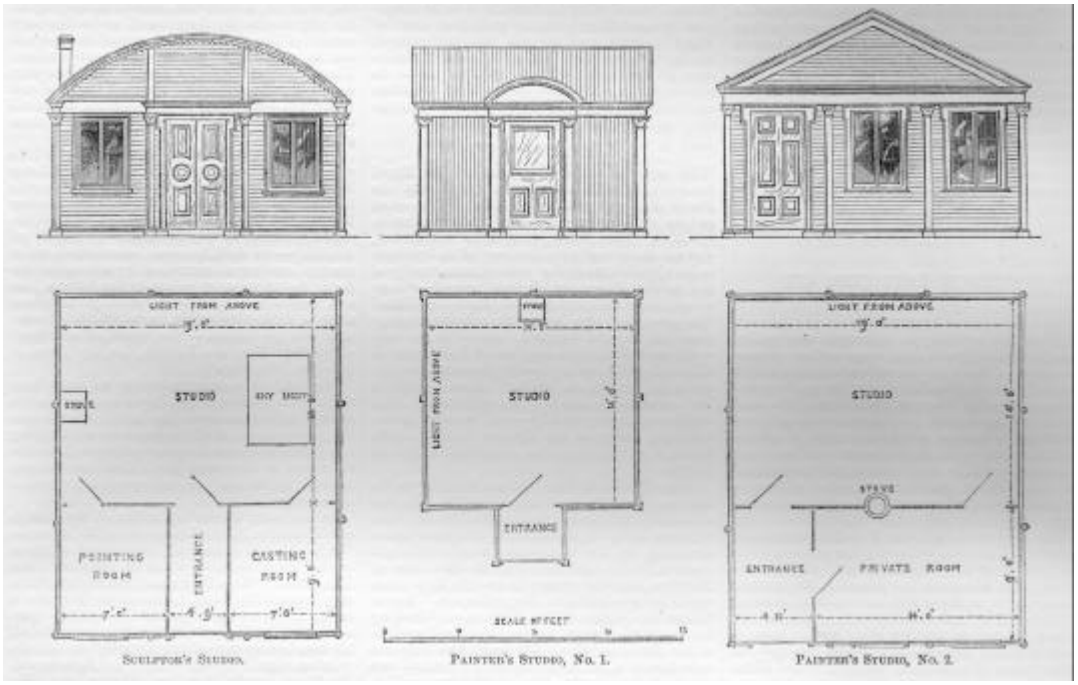
The emigrant's cottage caught the attention of Prince Albert. The Prince Consort admired the technical ingenuity in the construction of the cottage and subsequently ordered an iron building for Balmoral Castle, which at the time was under construction. The 60 × 24-foot build-

ing was to be used as a ballroom, dining room and private theatre. It was probably Albert's intention that the building would provide a quick but temporary space for these purposes during the building of Balmoral, which was not completed until 1856. Delivery of the iron ballroom was indeed speedy. Within a few weeks of receiving the order, Bellhouse wrote to Sir Charles Phipps, Keeper of the Privy Purse, advising him that the building would be ready within a week. Two weeks later, the building was packed, crated and sent by train from Manchester to Inverness.[26] The building was used by the Royal Family at Balmoral from 1851 to 1855.[27] Since the ballroom had no fire or artificial light, it probably saw limited use. It still stands today on the grounds of Balmoral, but has been converted into a joiner's shop.[28] This building shows one further step in the evolution of Bellhouse's work. The corrugation in the iron walls ran horizontally rather than vertically. The benefit of this was that the sheets could span eight feet between supporting columns without any intermediate framing. With the corrugation running horizontally, there were complications at the junction of the sheets and supporting columns. Bellhouse solved this by producing a special column with longitudinal ribs curved to fit the ends of the corrugated sheets. He later patented this invention[29] and used it in later buildings. The ballroom was widely reported and greatly admired. The *Illustrated London News*, in a romantic mood, described the building when seen from a distance as a "large cottage ornée."

Ballroom at Balmoral Castle[30]

The Great Exhibition provided one more avenue of demand for Bellhouse's prefabricated iron buildings. An art colony was growing up in Kensington near the Great Exhibition grounds. Kensington, then a suburb of London, was a preferred location for artists. It had better light because of its cleaner air, compared to the City; it was also quieter than the City. At least one artist saw the prefabricated buildings at the Great Exhibition and ordered one from Edward Bellhouse to use as a studio. In a letter to *The Art-Journal*, this artist described the need for a suitable studio as, "There is no doubt a want among artists, both painters and sculptors, of readily built studios of simple construction, allowing toplights as well as sidelights, which as the artist might change his residence he might remove."[31] After reporting that he had bought a prefabricated iron studio, the artist went on to say, "Several considerations appear to render such kind of building available for studios for artists, who find considerable difficulty in obtaining proper ateliers, any building erected for another purpose being rarely convertible into a fitting apartment for this purpose without considerable sacrifices and expense, which landlords are not always ready to take on themselves." Following this letter the editors of *The Art-Journal* received several inquiries from people interested in prefabricated studios. In a later issue they provided plans for three studios from E.T. Bellhouse and Co. that were priced from £60 to £130 when erected in London. These buildings were in demand into the 1870s. The artist George Frederick Watts ordered a studio in 1874, which he dubbed the "Tin Pot."[32] Watts' iron studio was made to his own specifications. It consisted of two studios, one for himself and the other for another artist Edward Burne Jones.

The editors *The Art-Journal* also remarked that iron buildings would be useful for temporary or travelling exhibitions of art. This suggestion came to fruition about two years later. In 1857 Manchester held its first Art Treasures Exhibition in which a large worldwide collection of art was assembled and exhibited. One Manchester resident, a Mr. Ogden of Long Millgate, had his own collection of paintings, antiques and curios that he wanted to display to the Exhibition visitors. For £400 Bellhouse was commissioned to put up a 65 × 32 foot exhibition building to house Ogden's collection. The building consisted of a cellar made of brick and an upper room with corrugated iron walls. Natural lighting was achieved by a raised roof so that the entire wall space was available for display purposes. The amazing thing about the building was the entire operation, including the manufacture and erection of the materials, took only thirteen working days.[33]

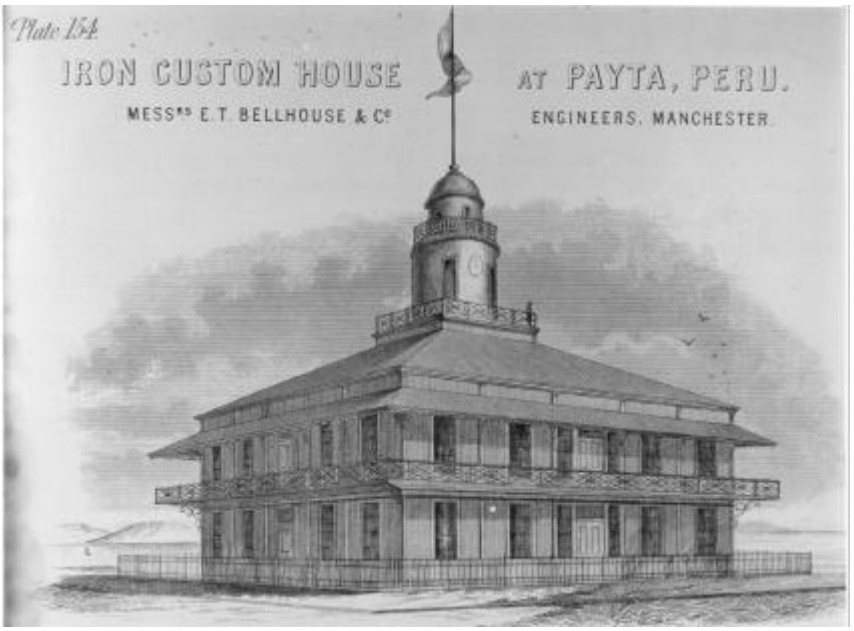


Artists' Studios Offered by E.T. Bellhouse[34]

Architecturally, Edward Bellhouse's best work was a customhouse built in 1854 for the Peruvian government to be erected in the northern end of the country in the town of Payta.[35] Edward Salmons, a talented young Manchester architect, designed the building. It was one of the rare instances when an architect collaborated in the building of prefabricated iron buildings. The building was 70 feet square and 75 feet high. It consisted of two main stories, a third story with a sloping roof, and two circular towers at the top, one on top of the other. The first two stories were surrounded by verandahs with decorative iron railings. The uniqueness of the building attracted considerable interest. The building and a warehouse bound for the same destination were erected in Bellhouse's yard prior to the shipment to South America. The site was visited by 25,000 people in ten days.[36] Although it was intended for Payta, the customhouse was erected in the neighbouring town of Piura.[37]

The customhouse was the first of a number of South American building contracts for Bellhouse that spanned about 15 years of activity. Edward Bellhouse erected more customhouses, but with the exception of the one intended for Payta none have been recorded.[38] Other South American buildings were connected with the railways. In the late 1850s Bellhouse constructed iron railway stations for the Canagalla Railway at Rio de Janeiro in Brazil.[39] In 1860 he sent out another railway station and an engine shed for the South Railway at Santiago, Chile.[40]

The engine shed was a roundhouse consisting of 48 sides. In the centre eight sets of track met at a central turntable so that the engine and tender could be shunted onto any of the radiating lines. Finally, in about 1870, Bellhouse built some railway stations for the Arequipa Railway in Peru.[41] Bellhouse's activities in South America were not unique. Unlike the California Gold Rush, there were a number of engineers active in South America.[42]



Customhouse Erected at Piura, Peru, 1854[43]

Following on his work in iron buildings, Edward Bellhouse developed a method of fire-proofing buildings.[44] This method, patented in 1853, is directly related to his other 1853 patent for iron columns to hold corrugated iron sheets. Similar to the ribbed columns for the iron buildings, the transverse iron beams under the floors of the building were also ribbed to receive the ends of corrugated iron sheets. The space between the floor and the iron sheets were filled with sand or concrete. Another patent application that is probably related to his work in iron buildings was made in 1855 with David Longsdon, a civil engineer in London.[45] This application, which received provisional protection only, was for improvements in the manufacture of materials for coverings for buildings. A felted material was combined with a netting of metal or cord to strengthen the felted material. The 1854 customhouse for Payta was lined with boarding and finished with a layer of felt, lining paper and coloured paper hangings. Bellhouse made a further patent application in 1867 for the construction of fireproof floors in buildings.[46] This

application also received provisional protection only. Bellhouse suggested an arrangement of the bricks under the floor that would yield a flat ceiling, rather than an arched one, when plastered over.

One of the features of the construction industry during the nineteenth century was that it was slow to mechanize. For example, hand sawyers were still working in sawdust as late as 1840[47] and the first satisfactory brick-making machine was not made until 1856.[48] As is evident from the discussion in Chapter 2 of David Bellhouse senior's steam-powered woodworking equipment and sawmill, the Bellhouses were near the forefront of the move to mechanization. The general trend of earlier generations of Bellhouses was followed with great enthusiasm by Edward Taylor Bellhouse. At the Great Exhibition of 1851 Bellhouse displayed a brick-making machine. Throughout the 1850s and 1860s, Bellhouse advertised in the Manchester directories that he manufactured brick making machines. Another area that he pursued for increased mechanization was that of marble cutting and polishing. In 1853 and 1855, Bellhouse and John Knowles, a Manchester marble merchant, applied for patents for inventions in this area. The first patent was for a revolving cutter of iron or steel in conjunction with a template. It was used for polishing, cutting and grinding curved edges or surfaces of marble slabs.[49] The finished products would be used as mantelpieces and tables. The second patent was for smoothing the marble just prior to a final polishing.[50] It was mentioned in the 1855 patent specification that previous methods had employed manual labour only.

Lower Campfield Market, now the Manchester Air and Space Museum[51]

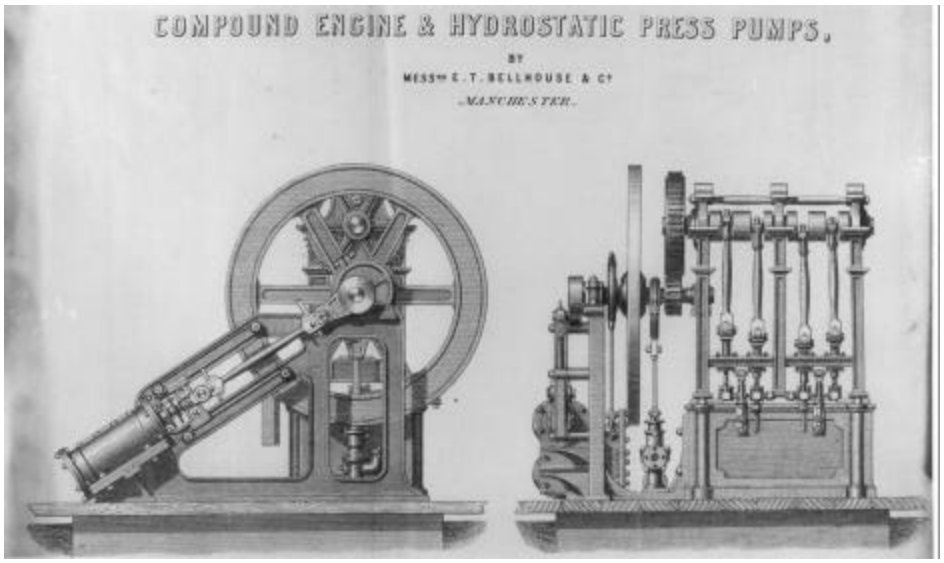
Throughout his career Edward Taylor Bellhouse listed millwright in the Manchester directories as one of his company's areas of activity. After apprenticing as a millwright engineer, he probably began his career manufacturing iron beams and columns for his father's construction activities. The manufacture of ironwork for buildings and the construction of large roofs both for the city and for private enterprise later became the principal part of his Manchester business.[52] In 1875 Bellhouse was responsible for the ornamental ironwork at Brook's Old Bank in Altrincham, which was built in the old style of a timber and stone façade called the "black and white" style.[53] He also made the iron beams and supports a year earlier for Mendel's warehouse in Chepstow Street, Manchester.[54] The only remaining examples of buildings by Bellhouse are the Campfield Markets in the Castefield area, built for Manchester Corporation to the designs of architects Mangall and Littlewoods in 1877. There are two buildings, originally separated by St. Matthew's Church, which is now demolished. At first, the buildings were open-sided, but were closed towards the end of the nineteenth century. At that time a gallery was added to the lower Campfield Market and it became known as the City Hall. In 1980 this building was restored to house the Manchester Air and Space Museum.[55]

The casting of iron beams at Bellhouse's Eagle Foundry was an activity that dated back to his father and grandfather's time in the 1820s or before. Likewise, there was another activity at the foundry that dated to the same era. In the Liverpool directory of 1824 there is mention that the firm of David Bellhouse and Sons was manufacturing blocks and pumps. Now pumps are one of the basic ingredients of the hydraulic press, another area of activity taken on by Edward Taylor Bellhouse. There is no evidence to confirm that Eagle Foundry was manufacturing hydraulic presses before Edward Bellhouse took it over in 1842. However, since hydraulic presses were used in the cotton industry and since David Bellhouse senior ran a cotton mill, the atmosphere was conducive to this activity.

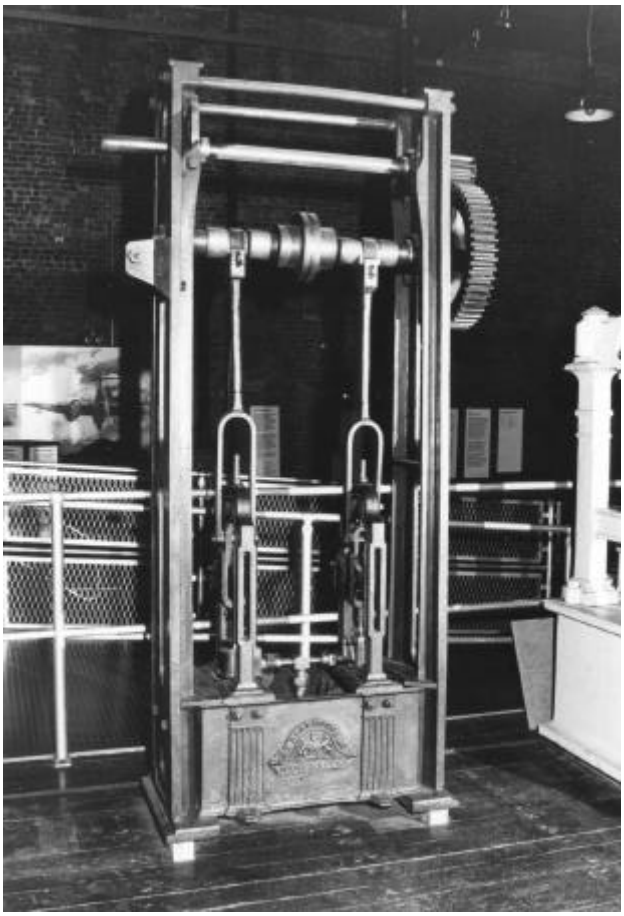
The hydraulic press was originally developed and patented by the brilliant Yorkshire engineer, Joseph Bramah. In fact, most of the basic elements of the hydraulic power industry were conceived by Bramah. The hydraulic press was a vast improvement in terms of power over the screw press that had changed little since Roman times. Bramah's presses were used mainly to extract oil from seeds or to bale wool, cotton or hay. Further major developments of interest in hydraulic machinery were due to William Armstrong, another Yorkshireman. He developed the

hydraulic crane in 1846 and probably built the first hydraulic elevator in Europe. By 1854 Elisha Otis in the United States had constructed hydraulic elevators.[56]

From the time he entered business in 1842, Edward Taylor Bellhouse manufactured both hydraulic and screw presses. Much of Bellhouse's work in hydraulic presses is related to its use in pressing cotton into bales. This is understandable in light of Manchester being a major cotton centre. The earliest mention of Bellhouse's work in this area is the Great Exhibition of 1851.[57] Bellhouse, in addition to his model emigrant's cottage and other articles, exhibited a hydraulic press for packing cotton. It won an honourable mention in the juried competition. Bellhouse's press was typical of the time in that it was operated by hand pumps.[58] During the 1850s there was a change to steam power for driving the presses. Bellhouse also changed with the times. He manufactured compact steam engines and press pumps that were used in warehouses where smaller presses were required. One of his hydraulic pumps survives and is preserved in the Manchester Museum of Science and Industry. Bellhouse was also involved in some of the developments taking place in the 1850s. In 1857 he and William Dorning, another Manchester engineer, developed a safety valve that threw the pumps out of gear when the water pressure became too great.[59] Although his major application for presses was cotton, Bellhouse put his presses to other uses. In 1854 he constructed a press for packing bales of hay. The press was sent to the Crimea for the British Army.[60]



Hydraulic Pump Driven by an Engine[61]



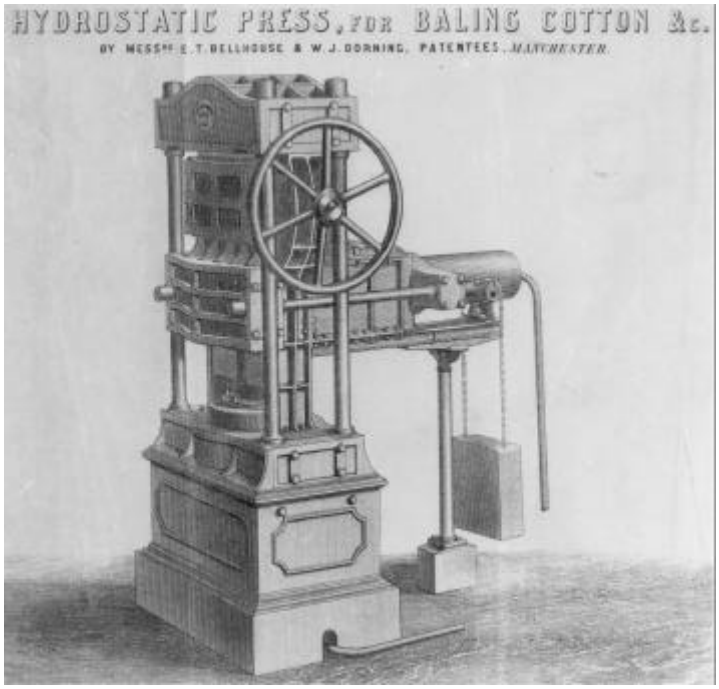
Hydraulic Pump in the Manchester
Museum of Science and Industry[62]

These hydraulic presses and pumps were installed in cotton warehouses and factories. Here is a description of the machinery Bellhouse supplied for a newly built warehouse in 1868.[63]

> "In the lower cellar the machinery is fixed, comprising two 30-horse engines, two 40-horse boilers, together with the gearing and the hydraulic pumps connected with the packing presses. … The upper cellar is devoted exclusively to packing by powerful hydraulic presses, arranged round the sides of the packing-room. The whole of the hoists, cranes, pumps, &c. are worked by steam from the boilers, which are placed under the loading gateway, on a level with the lower cellar."

Bellhouse's interest in hydraulic presses received a stimulus from the American Civil War (1861 – 1865). Of importance to the cotton industry was the Union (the northern states) blockade of the Confederate (the southern states) ports beginning in April of 1861. The blockade

was not effective until mid-1862. The blockade and eventual seizure of some Confederate ports greatly reduced exports of raw cotton to England.[64] English merchants looked to other countries for their cotton, India as a first choice and then other countries such as Egypt. In 1862 Bellhouse and Dorning patented a press suitable for packing cotton.[65] It combined both vertical and horizontal hydrostatic presses. The cotton was introduced through a trap door into a horizontal box. The vertical ram then compressed the material in the vertical direction. Bellhouse manufactured this high-powered press originally for use in India. To reduce shipping costs, it was important to compress the cotton to the smallest volume possible. The press was capable of packing 400 pounds of Indian cotton into 12 cubic feet.[66] In 1865, while the cotton famine was still ongoing in England, Bellhouse went to Egypt to examine methods of packing cotton there. While he was in Egypt he noticed the poor methods that were being used, especially with rope, to keep the bales of cotton together.[67] Ever the inventor, he developed a simple fastening device using the iron bands that were used for making the bales. The ends of the bands were bent into J-shapes so that they would fit into one another and a flat band was slipped over the joint to complete the fastening. Bellhouse wrote from Egypt to Dorning who then applied for the patent.[68]



Hydrostatic Press for Baling Cotton

Throughout the American Civil War and until a few years thereafter, Edward Bellhouse continued to work with Dorning on cotton packing methods. In 1865 they applied for a patent for improvements to the cylinder of the press.[69] The cylinder, which sustained the hydraulic pressure, was made lighter and more portable, but retained its strength. In the same application, they reported a novel way of fastening and unfastening the confining bars surrounding the boxes that held the cotton. The last collaborative work was in 1868.[70] At the time they patented improvements to the press itself. The problem that had encountered was that the final pressure required was greatly in excess of the pressure required in the main stroke of the ram. They solved this by using three rams. The outer rams were used throughout the stroke while the third ram came into action when additional pressure was required. By using this method they were able to use a shorter central cylinder and pumps of smaller capacity.

Not all of Bellhouse and Dorning's work had specific application to cotton packing. In 1864 and 1866, they patented improvements to the stopcocks, valves and pumps used in the presses. The 1864 invention prevented the return of water to a pipe as soon as the valve started closing rather than at the complete closure of the valve.[71] The 1866 invention prevented a further supply of water to the presses as soon as a desired pressure was obtained. It also dealt with the arrangement of the pumps and machinery so that cleaning the pipes and pumps would be easier.[72] A final 1866 patent was unrelated to cotton packing.[73] In this patent Bellhouse and Dorning applied hydraulic presses to the making of small iron hardware articles such as keys, wrenches, cotters and nuts. These had previously been made of cast iron. They proposed making a die and matrix for the article and then punching it out with a hydraulic press.

Bellhouse also applied hydraulic machinery to lifts and hoists. However, this came much later in his career. His early work in this area, beginning in about 1845, did not involve hydraulic machinery. This was a fireproof hoist used in mills and warehouses. Previously hoists had wooden doors. If a fire broke out, the doors were soon burned. The hoist shafts then provided an upward draught for the fire causing it to spread quickly. The doors of the new hoist were of wrought iron boilerplate and were shut by means of a cradle. The frame of the hoist was also of iron.[74] He showed this hoist at the Great Exhibition of 1851.[75] In 1849, those using the hoist in preference to other types of construction were given lower fire insurance premiums on their buildings.[76] Some improvements to this device were attempted. In 1854 Bellhouse and a Manchester oil merchant, Robert Thomas, developed a method using ratchet gears rather than

winches to communicate the rotary motion to the hoisting apparatus.[77] By the 1860s Bellhouse was using power, probably steam power, for his hoists.[78] Later he constructed hydraulic lifts and hoists. His only hydraulic hoists on record are the ones he manufactured for the Manchester Town Hall in 1877.[79] One hoist ran from the basement to the kitchen on the third floor, and communicated with the mayor's private dining room. Two other hoists were used to raise coal and other materials from the basement to various floors. All three were worked by hydraulic pressure from the street mains. They were described as "ingenious in construction and efficient in operation." Edward Bellhouse's son, Sidney, was probably involved in this venture since he appears on the guest list with his father for the ball celebrating the opening of the Town Hall.

Edward Taylor Bellhouse also had some minor interest and dealings in waterpower other than hydraulic presses and hoists. In the 1860s he was manufacturing waterwheels and turbines.[80] In 1879, two years prior to his death, he read a paper on water motors to the Association of Employers, Foremen, and Draughtsmen.[81] In the paper he described how water motors, driven by pressure from the city's mains, could be used economically when motors of small power were required. This would yield savings over steam engines because of the cost of coal.

Boiler making was another activity at Eagle Foundry. Again, like most of his other activities, Bellhouse was engaged in boiler making within about a decade of his entering business. In 1853 Bellhouse built an engine boiler for £93 for the Worseleys at Platt Hall. The work included fixing and then replacing some old force pumps, and supplying steam gauges, steam cocks, brass taps and over a thousand feet of pipe.[82]

Bellhouse was not only a supplier but also an investigator in this area. Beginning in the 1850s, Bellhouse obtained or applied for patents for improvements to boilers. Two of the patents are related in terms of their objective, namely to try to obtain the maximum surface area of water available for heating. In the first patent, granted in 1853, this was achieved by having parallel twin boilers with internal furnaces and a tubular chamber between the boilers.[83] The smoke and gases passed through the main flues of each boiler and then into the cross flue. The central chamber contained a number of tubes connecting the water in each boiler. The second patent, granted in 1857 jointly with William Dorning and which received provisional protection only, shows Bellhouse's continued fascination with corrugated iron.[84] The internal flues of the boiler were corrugated on the upper side. Vertical waterways were fitted across the flues thus increasing the contact with the water and increasing the amount of steam generated. One other patent

for steam boilers was obtained in 1855 with Thomas Cowburn, an engineer at Eagle Foundry.[85] They invented a safety valve that allowed either steam to escape when the pressure was too high, or air to enter if a vacuum was formed when the water level was too low.

Also in the 1850s, Bellhouse engaged in coal gas engineering. He manufactured both gasometers and gas storage tanks for the domestic market.[86] At a higher profile, he obtained some large contracts to erect gasworks at Athens, at Pernambuco in Brazil, and at Buenos Aires. No further information has come to light on the first two of these undertakings.[87] The Buenos Aires gasworks, erected in 1856, was an enormous operation.[88] At least two thousand tons of material was sent to Argentina from England in ten ships. Over 6,000 lineal yards of street mains were laid. The contract was for the entire operation including the gas-making plant, retort house, coal stores, purifying house, gasholder tanks and furnaces. The gasworks were situated on the banks of the Rio de la Plata north of the city's piers.[89] The local work to erect the gasworks was undertaken by William Bragge, originally of Birmingham but then living in Buenos Aires.[90] Bellhouse visited the gasworks probably as they were being erected. He arrived in Buenos Aires on August 22 of 1856 with his wife Sarah and a servant. They departed on October 4.[91]

Gasworks at Buenos Aires pre-1863[92]

Late in his career, Edward Taylor Bellhouse became interested in gas engines.[93] This would have been coal gas not the modern gasoline. Although he appears to have done no work in the manufacturing or development of these engines, his musings in 1879 about the future of such an engine show his ability to grasp the potential of new developments. More than one discussant of the paper disagreed with the substance of his musings; one of the discussants stated that he could see little hope for the induction of the gas engine in connection with the locomotive.

The breadth of Edward Taylor Bellhouse's involvement in the cultural life of Manchester is of the same scope as his wide-ranging interests and activities in business. As in business, some of his interest in the arts can be traced to family influences. Also, some of his business activity reflected his interest in the arts. This interest in the arts led to an involvement in the foundation of the Brasenose Club.[94] Although he was not among the signatories of a letter proposing the foundation of the Club in 1870, his name appears in the first printed list of members of the Club in 1870. He was also president of the Club for three years. The Brasenose Club specifically attracted people with an interest in the visual arts, theatre and music.[95]

Edward Bellhouse's interest in music, together with his administrative abilities, was recognized early. In 1845 he was asked by Robert Weston to be a member of a committee for the Lancashire and Cheshire Working Man's Singing Classes, later the Lancashire and Cheshire Philharmonic Institute.[96] He declined because of lack of time but donated money instead. Later in 1852 he found time to become president of the Manchester Gentlemen's Glee Club, a club in which his father had been very active.[97] Weston must have convinced Bellhouse at a later date to find time for his own group. It is stated in Bellhouse's obituary that he was "the chief promoter of the Philharmonic Society."[98] The Society was probably the same organization as the Institute: under Weston's direction it provided classes for vocal study and practice, and also provided inexpensive concerts. Edward Taylor Bellhouse was also a director of the Concert Hall and was involved in several other musical societies.[99]

Edward Taylor Bellhouse was known as a connoisseur in pictures and other works of art. Again his interest was combined with his administrative talents. He served as a governor of the Royal Manchester Institution.[100] Bellhouse's knowledge of art can be seen in the guides that he wrote for art exhibitions in 1857, 1878 and 1881.[101] The 1881 exhibition, because of his commentary on the paintings, shows some of his taste in art. Of the 22 artists represented at this exhibition, mostly contemporary English artists in both oil and watercolour, half are still in de-

mand today and another three or four are in moderate demand. Assuming that his comments, which were all positive, indicated his preference in art, then it may be concluded that he enjoyed landscapes, religious and genre paintings. Of the seven painters he singled out for particular attention, at least three of their paintings in the 1881 exhibition are now in museum collections. All these painters' works are in demand today. Interestingly, one painting that he made no comment on, *Lake Como* by Stanfield, is now in the Tate Gallery.[102]

Bellhouse also maintained an interest in the theatre. Unfortunately, there is no information of his activities in this area beyond an interest in local theatre, especially the Theatre Royal.[103] There is one instance, as in art, in which his theatrical and business interests coincided. Through the actor G.V. Brook, Bellhouse received an order to build the 300 seat Royal Olympic Theatre in Melbourne, Australia. Costing £4,000, the theatre was another of Bellhouse's prefabricated iron buildings. It was the first theatre constructed of iron. The *Guardian* reported in 1881 that the building could be taken down with ease and carried from place to place so that Brooke would be immune to the exorbitant demands of theatre proprietors in Australia. This was a fanciful exaggeration. The outside of the theatre had corrugated iron walls. However, much of the building was encased in brick and the façade had many large plate glass windows.[104]

Like his grandfather before him, and to a certain extent his father, Edward Taylor Bellhouse took an interest in improving the lot of the workingman in Manchester. For Edward Bellhouse it appears that his religious beliefs were a strong motivating force for his efforts in this area. His uncle, John Roberton, also appears to be influential in some of Bellhouse's charitable work.

One of the vehicles for social reform in Manchester was the Manchester Statistical Society. Roberton joined the Society in 1838 and was its president from 1844 to 1847.[105] He had wide-ranging interests in social reform. Of importance here is Roberton's interest in public health; it probably sparked a similar interest in his nephew Edward. In 1848 Edward Taylor Bellhouse was a member of the Health of Towns Association.[106] Earlier, during Roberton's presidency of the Manchester Statistical Society, Edward Bellhouse was joint secretary with James Dunn in the founding of an experimental bath and washhouse establishment in Miller Street. As mentioned in Chapter 3, Edward Bellhouse's brother Frank was the architect for the building. The first movement to provide public baths and washhouses was in London in 1844. The Manchester venture began in 1846. Edward Bellhouse served on the governing committee of

the Miller Street Baths and Washhouses for 14 years. The object of the experiment was to provide public baths and laundries to improve the cleanliness of the population. The hope was that this would reduce the spread of virulent infectious diseases.[107] In an 1853 paper read before the Society, Roberton suggested, as a means of improving public health, the demolition of back-to-back housing and the establishment of publicly owned crèches, washhouses and baths.[108] Later in the same session of the Society, Edward Bellhouse read a paper on baths and washhouses. He also noted that these establishments were increasing in public popularity.[109] He made the case that these operations were profitable and could be run by the city with no drain on the public purse. Twenty-three years later, Bellhouse read another paper before the Society on baths and washhouses in which he traced the progress that had been made in the interval. This progress had been made by private means and he expected that within a year, Manchester would finally provide public baths and washhouses.[110]

For three or four generations the Bellhouses attended Nonconformist chapels or churches. Edward Bellhouse's uncles by marriage were also strongly connected to this chapel tradition. John Roberton attended Mosley Street Chapel and was known as a pious puritan.[111] Samuel Bradley was the minister at Mosley Street Chapel.[112] Despite these strong family connections, Edward Taylor Bellhouse conformed to the Established Church, attending Holy Trinity, Hulme.[113] He did maintain the strong Protestant ethic that could be associated with his family. He considered it better to improve oneself through study than to get caught up in other "alluring temptations."[114] In this regard he practiced what he preached. For Christmas of 1862, he gave one of his sons the first volume of Gosse's *Romance of Natural History* and the second volume to another son. He also devoted himself to Bible study; some notes on texts relating to baptism are written on the flyleaf of his own Bible.[115] One of Edward's sons, Herbert Lafone Bellhouse (1849 – 1907) entered the ministry in the Church of England; he held various curacies in Lancashire parishes and served as vicar of St. Mary Magdalene, Clitheroe from 1892 to 1902.[116]

Edward Bellhouse's beliefs reflect his attitudes in relation to the workingman. He was an early promoter of the Manchester Athenaeum, a library founded to provide newspapers, books and lectures for young middle class men, and he established a scientific library at Eagle Foundry. He devoted much effort to the Mechanics' Institute, holding the office or vice-president for some time.[117] In 1879 he was president and promoter of the Mechanics' Institution Literary and Discussion Society. Its purpose was to train members to form and express verbally sound argu-

ments and opinions.[118] Further interest in technical education, and awareness of the problems involved, are found in two papers Bellhouse wrote on the subject. One was delivered to the Manchester Statistical Society[119] and the other to the Association of Employers, Foremen and Draughtsmen when he became president of that organization.[120]

His beliefs also had an effect on his attitude to the growing union movement. He believed that the purpose of unions was to provide services as a benefit society and that it was not a tool through which workmen should increase their wages. This latter purpose was to be achieved by bargaining between each individual and his employer, an attitude that is very much in line with the Protestant ethic. In an 1852 strike of moulders, mechanics and labourers in Manchester, Bellhouse ran a newspaper advertisement stating that employment could be obtained from him provided that the workmen signed documents swearing that they were not union members and they would not join a union, other than one set up as a benefit society.[121] This practice was common among employers at the time; several other employers ran similar advertisements during the same strike.[122]

Edward Taylor Bellhouse was well respected in Manchester. That reputation helped in an assault case in 1867. One evening in August of that year Bellhouse was talking a walk near his house along the road between Timperley and Sale.[123] He noticed two individuals about 150 yards down the road preparing to run. He crossed the road to the footpath, which was about three yards wide. After walking another 25 yards he noticed the two individuals running toward him. He stopped and stood still. As they were running past him, one of the runners brushed Bellhouse's shoulder and knocked him into a wall. After picking himself up, he angrily swore at the runners. This was reported in the ensuing court case as,

"He [Bellhouse] rose up and used cursory language.

Mr Baron Martin [the judge]: Do you mean cursory or cursing?

Witness [Bellhouse] said the court might take it either way.

Laughter."

Bellhouse reported the incident to the police and returned home. The runners were John Fleet, described as a "professional pedestrian" and his trainer Charles Cooper. They had a different story. They were training for a race by running up and down the path. After the first sprint up the path, they met and passed Bellhouse on the return sprint down the path. On the third sprint they claimed Bellhouse struck Cooper with his fist. As a result Cooper ran into Fleet who fell against

the stone wall beside the path and cut his arm. Two days later Cooper consulted a lawyer and brought an action against Bellhouse for assault claiming that he was unable to compete properly because of the injury. The judge advised the jury that it was up to them to decide which story to believe and they found for Bellhouse. There may have been other factors that were in Bellhouse's favour other than his reputation. The locals had complained in the past about how annoying these footraces were. Further, their running attire may have offended some Victorian sensibilities. They were wearing only "drawers and shoes" that were described as "even of a lighter description than that adopted on the stage by a popular actress."

Like his father and uncles before him, Edward Taylor Bellhouse migrated to the suburbs. Until the 1860s Edward Bellhouse resided in Chorlton on Medlock.[124] As his father became aged, Edward appears to have taken over his father's house near Altrincham.[125] In failing health, a few days before his death on October 13, 1881, Edward moved to Southport to avoid the winter in Manchester.[126]

Two of Edward Taylor Bellhouse's children entered the family business. His youngest son, Sidney Lafone Bellhouse (1851 – 1883) worked at Eagle Foundry, probably in the area of hydraulic equipment. It has been noted already that Sidney was on the guest list, along with his father, for the ball celebrating the opening of the Manchester Town Hall in 1877.[127] The firm had been responsible for installing some hoists in the new Town Hall.

Edward Taylor Bellhouse's eldest son, Edward Lafone Bellhouse (1848 – 1924), eventually took control of Eagle Foundry. Under the son's direction, the company continued to produce hydraulic presses and boilers.[128] Edward Lafone Bellhouse obtained patents in 1886 and 1888 for improvements to hydraulic presses used for packing cotton. The 1886 patent follows on his father's patent of 1868 for hydraulic presses.[129] What the son achieved in the 1886 patent was a method of obtaining the same hydraulic pressure for packing as his father but with the use of only one pump. The second patent, granted in 1888, was an improvement on the earlier method of 1886.[130]

Over the 1880s the business declined. The entries for E.T. Bellhouse and Co. in the Manchester directories become progressively smaller over the years 1882 to 1892 and disappear in 1893. On Goad's 1893 insurance map of Manchester, in the place where E.T. Bellhouse and Co. had previously been seven years before, there is no name attached to the buildings on that part of the map.[131] The buildings were either in transition or were derelict. The company was resurrected

briefly under a new name, M.L. Bellhouse and Co. after Edward Lafone Bellhouse's wife, Marie Louise, née Atterbury. The listings for this company appear in the 1893, 1894 and 1897 directories and the place of business was Whitworth Street, the same street for the location of the original company. By 1903, Edward Lafone Bellhouse was working for Heenan and Froude Ltd., Manchester engineers, bridge builders and contractors.[132] The Manchester directories of 1906 and 1925 list the firm of E.L. Bellhouse and Co. at 61 Piccadilly. The description of the company's operation was merely given as "engineers, agents."

Marie Louise Bellhouse[133]
(1852 – 1926)

Edward Lafone Bellhouse[134]
(1848 – 1924)

At least until the mid-1890s, Edward Lafone Bellhouse resided in Ashton upon Mersey in a house called "The Croft" on Queen's Road. By the end of his life, he was residing in the Peak District in Derbyshire in the town of Buxton.[135]

Several sons and grandsons in succeeding generations became engineers. Unfortunately, information on some of these individuals and their careers is quite sketchy.[136] Edward Lafone Bellhouse and his wife, Marie Louise, had two sons and three daughters. Both boys, Edward Lafone Atterbury Bellhouse (1879 – 1950) and George Herbert Atterbury Bellhouse (1882 – 1951) were engineers. They received their initial training as engineers from their father. Edward was an electrical engineer with premises in Oxford Street in Manchester.[137] The younger brother George was trained as a Naval Engineer, rising to the rank of Chief Petty Officer in the Royal Navy during the First World War; the elder brother served in the Royal Flying Corps. After the war Edward Bellhouse re-

turned to the Manchester area. He lived in Combs, a village about ten miles away from Buxton. On the death of his father in 1924, his family moved to Buxton to live with his mother, Marie Louise Bellhouse. George Bellhouse settled in Rye, Sussex, after the war where he established a company known as the Rye Engineering and Trawler Company.[138]

Edward Lafone Atterbury Bellhouse (1879 – 1950)

George Herbert Atterbury Bellhouse (1882 – 1951)[139]

George Bellhouse's move to Rye resulted in two of his siblings moving there in the 1920s. One of his sisters, Constance Mary Bellhouse (b. 1875) was the Librarian and Secretary for The National Library for the Blind in Manchester from 1917 to 1924. Earlier she had worked in Henshaw's Blind Asylum in Manchester.[140] As a career woman she supported the Suffragette Movement.[141] By the early 1920s she had developed exophthalmic goitre. In 1924 she resigned her position in the library because of poor health and moved to Rye. There she operated the Old Hope Anchor Hotel. Her brother Edward, on the advice of his doctor, also moved south to Rye for "health reasons." In 1918, he had developed diabetes mellitus. The move to Rye was made after the death of his mother in 1926.

There are also engineers among the children of this generation. The eldest son of Edward Lafone Atterbury Bellhouse, Edward David Bellhouse (d. 1972) eventually became an electrical engineer; he worked at several atomic energy installations across Britain. Initially, he trained at his uncle George's engineering works in Rye. Sometime before

the Second World War he moved to London where he worked as an engineer. Following the war he moved to Winchester where he set up shop as a gunsmith with one of his brothers, Gerald Eden Bellhouse. When this did not work out, David Bellhouse entered the nuclear construction industry while his brother Gerald set up shop repairing and re-conditioning antiques. Another brother, George Lawrence Bellhouse, took up farming near Hastings.[142]

Luggage label from the Old Hope Anchor Hotel[143]

There is an interesting déjà vu in the work of Richard Lafone Bellhouse, another son of Edward Lafone Atterbury Bellhouse. During the excavations for the South Junction Railway in Manchester in the 1840s done by David Bellhouse (1792 – 1866), the workmen found an old Roman wall near Castlefield. At the request of the Earl of Elsemere, Bellhouse's men scarcely disturbed the wall.[144] Unlike his ancestor Richard Bellhouse became interested in the antiquities that he encountered on the job. In the early 1950s, more than 100 years after the construction of the South Junction Railway, Richard Bellhouse began recording the Roman roads he saw while working as a drainage officer in Cumberland for the Ministry of Agriculture.[145] In 1954 he discovered a Roman watch-tower on the Cumberland coast. Since that time he has uncovered what has come to be known as the "Hidden Frontier," the western end of the Roman defense system of which Hadrian's Wall is the largest and most visible part.[146] Over a period that spans 30 years or more, Richard Lafone Bellhouse has regularly published the bulk of his work in *Trans-*

actions of the Cumberland & Westmorland Antiquarian & Archaeological Society. In recognition of his work, he has been elected Fellow of the Society of Antiquaries.[147] In 1980 he was also presented with the Silver Trowel Award given by Legal & General Insurance as part of the British Archaeological Awards at the British Museum.[148]

The eldest son of George Herbert Atterbury Bellhouse, Francis Hewitt Bellhouse, was also an engineer. He trained with his father in Rye and then went to London in 1927, initially working for Daimlers. Near the end of the Second World War, Francis Bellhouse was in Shoreham overhauling landing craft. After the war he returned to his father's business in Rye. He carried on this work until the late 1960s when he sold the garage and went to Oxford to work with his son. He was initially appointed as a Machine Shop Technician at Oxford University. Later he was promoted to the academic-related rank of Design Engineer.[149]

The only son of Francis Bellhouse is Brian John Bellhouse (b. 1936). He was educated at Oxford where he received his B.A. in 1960 and D.Phil. in 1965. In 1962 he became a Fellow of Magdalen College. Since his doctorate he has held various faculty positions at Oxford.[150] From the mid-1960s Brian Bellhouse has been publishing theoretical and experimental work in the general area of the fluid dynamics of blood.[151] This work has led to the development of various medical devices, some of which have emanated from joint research with his father. There are four distinct facets to Brian Bellhouse's work in the development of medical technology: the construction of artificial hear valves; the construction of instruments that measure blood flow in the body; the development of a device that supplies oxygen to the blood during open heart surgery and heart transplant operations; and the development of a needle-free drug delivery technology.

The first two facets of Brian Bellhouse's work began in the late 1960s as joint research with his father. In 1968 father and son published two articles in *Nature* related to the operation of the aortic valve in the heart.[152] They constructed an artificial aortic valve made of nylon and silicone, and studied the fluid dynamics of this valve. The new valve was mechanically and hydrodynamically more efficient than other known prosthetic aortic valves; the valve closed with the minimum regurgitation of blood. The same year they patented their new valve.[153] Related to this work, father and son developed a needle-

shaped probe that could measure blood flow in the body.[154] This was a useful device for open-heart surgery. The first probe they developed was limited in use to the major blood vessels; there was also a risk of damage to the heart valves and wall. Subsequently, the probe was improved upon.[155] Following his work on the aortic valve, Brian Bellhouse began work on the study of the fluid mechanics of another heart valve, the mitral valve.[156] Again, he was joined by his father in part of this research. After much testing, both in the laboratory on the fluid mechanics of the valve and *in vivo* on goats, the end result of this work was the development of a prosthetic mitral valve that simulated the operation of the natural mitral valve better than other artificial valves. The new valve was patented in 1977.[157]

The third facet of Bellhouse's work, although related to his previous work in the sense that it deals with blood flow, was a step in a new direction. Work in this third area continued into the late 1980s.[158] There was also another dimension to this research. Brian Bellhouse's wife, Elisabeth, became part of the research team that still included father and son. In the early 1970s Brian Bellhouse began work on developing and improving oxygenators for use in open-heart surgery.[159] Later the use of these oxygenators was expanded to include "prolonged, but temporary, support of patients suffering from acute respiratory distress."[160] Oxygenators, or artificial lungs, add oxygen to and remove carbon dioxide from a patient's blood during open-heart surgery when the heart is unable to pump blood through the patient's lungs. Bellhouse's first device in this area was patented in 1972.[161] Most blood oxygenators at that time worked by direct injection of oxygen bubbles into a blood reservoir. This damaged the blood and so bubble oxygenators could be used only for short periods of time. However, membrane oxygenators, which caused much less blood damage, were inefficient in gas transfer and their performance decreased still further with use as the membranes became fouled with blood proteins. Bellhouse's invention reduced this rate of decrease by pulsating the flow of blood through membrane oxygenators. In later patents, Bellhouse made several improvements to this membrane oxygenator and developments beyond it.[162] This included the important innovation of passing the blood in the oxygenator across a furrowed surface to get a better mix of the blood and oxygen gas. Bellhouse applied the same principles he used in the construction of the oxygenator to develop a blood plasma separator.[163] This device is useful for sur-

gery that had previously required blood transfusions. With this device, blood lost during surgery could be recovered from the patient and then cleansed, re-concentrated and re-infused, all during surgery. The machine has been used on patients who would previously have required a blood transfusion of up to nine units. Since no donated blood would be required, the risk of hepatitis or of infection from blood contaminated by the HIV virus is removed.[164] Other applications of this technology that have been pursued by Brian Bellhouse include elements of artificial lungs, dialysers and microfiltration units.

In about 1984 Brian Bellhouse developed another type of technology stemming from his work in blood. The lifetime of stored human platelets is highly variable with the usual maximal storage time at five days. This five-day shelf life can result in one of two problems. In some storage packs the platelets may be clinically useless within the five-day period. Other packs, which have expired, may actually be useful. Sampling from a storage pack to determine the viability of the platelet is time consuming and subjects the contents of the pack to the risk of infection. Bellhouse's technique was to monitor the quality of the stored platelet without opening the storage packs.[165] The technique was based on the knowledge that healthy platelets are disk-shaped and that these platelets deviate from this shape as their biological effectiveness deteriorates. Bellhouse's technique used laser technology to determine whether or not the platelets tested were discoid. A series of patents were obtained for this technique as well as several improvements to it.[166]

In order to protect his patent rights, Brian Bellhouse and his family set up the company Bellhouse Technology Ltd. in 1982. The principal shareholders and directors of the company at incorporation were Brian Bellhouse, Elisabeth Bellhouse and Francis Bellhouse. Elisabeth also served as secretary to the company until 1986.[167] As part of his research program, Brian Bellhouse carried out contract research for various companies. For example, the Johnson & Johnson Company[168] and 3M,[169] both of the United States, supported part of the development of the oxygenator. A second company, Bellhouse Medical Products Ltd.,[170] began operations in 1984 to handle the work for 3M. Again, the initial shareholders included Brian, Elisabeth and Francis Bellhouse. Bellhouse Medical Products grew quickly from its inception. Financial statements for the company show that the wages paid by the company more than doubled from £60,000 in 1984 to about £120,000 in 1985, and then increased to almost £200,000 in 1986. However, problems

were also encountered. There were delays in obtaining government approval for the equipment the company produced, which in turn affected sales negatively. The company operated at a loss for several years. The immediate solution was to increase the share capital of the company. The Charente Steamship Company Ltd. became a major investor in the company in 1985 and increased its investment the following year. Bellhouse Medical Products has gone through two metamorphoses in its business lifetime. Late in 1986 the company's name was changed to Engineering Bio-Sciences Ltd. At the beginning of 1987 the business activities, which included the manufacture and sale of medical products, were given to its wholly owned subsidiary, Bellhouse Bio-Sciences Ltd. The parent company provided only management services. Then in 1990, the company and its subsidiary were merged with Haemocell plc.[171] Brian Bellhouse remained a director of the company throughout this time, but by 1992 he was no longer a director. Government approval for the blood filtration device was finally obtained from the United States Found and Drug Administration in October of 1992.[172]

The fourth and latest facet of Brian Bellhouse's work is his development of a drug injection system without needles. He began in the early 1990s with the idea that a gun triggered by helium could inject drugs in powdered form subcutaneously.[173] Knowing that salt causes red blood cells to burst, he experimented on himself. He built a prototype apparatus and injected salt into his hand. After a few hours his skin began to bleed from the salt penetrating below it and he knew that the experiment was successful. The whole procedure was painless. Bellhouse's daughter Elspeth immediately saw the potential for the device. So did another, Paul Drayson, a businessman with a scientific background in robotics. Drayson estimated that in the future about 10% of drugs would be administered through the kind of injection system developed by Brian Bellhouse.[174] The system was then developed through a company called Oxford BioSciences set up in 1993 by Bellhouse and Drayson. Elspeth Bellhouse was the marketing director. A year later she married Drayson. Initially, Brian Bellhouse and Paul Drayson between them held about 60% of the stock in the firm. Oxford University held another 8% of the company in return for its share of the patent rights. Other investors included venture capitalists.[175] The first patent for the device was obtained in 1994.[176] This was followed by several improvements to

it including a method to recapture the active ingredients of the injection that were reflected, rather than absorbed, by the target surface.[177]

When developed, the device itself was the size of a pump-action toothpaste dispenser consisting of three parts: a helium cylinder, a drug cassette and a specially shaped nozzle to control the velocity of the particles travelling at supersonic speed. The new device has several advantages over drugs injected by needle. Many drugs become chemically unstable when dissolved in water; powder is not. Moreover, powder is easy to transport and may not need the refrigeration that some drugs in solution require. The device may also be more effective than a needle since the drug can be targeted more accurately.[178]

Drayson, the entrepreneur, developed the business side of the company, initially be securing venture capital. In the first few years the company devoted its resources to research and development, losing about £5 million by 1997. It was estimated in 1994 that it would be three to five years before the devices that were under development would see clinical use. In June of 1997, the company, now under the name of PowderJect Pharmaceuticals plc, was developed to such a point that stock was floated on the open market.[179] The initial offer of shares was twice oversubscribed. At the beginning PowderJect was a small company centered at Oxford and employing about 10 people. It has now expanded to have additional offices in Palo Alto, California with other United States offices in Wisconsin. The company employs over 160 people.

The company took on several clients including the pharmaceutical companies Ares-Serono, Roche, Chiroscience, Pfizer and Zeneca.[180] Early major collaboration was with Glaxo Wellcome for which PowderJect agreed to take Glaxo's proprietary drug brands of genetic vaccines for hepatitis B, AIDS and cancer, and then convert them to dry powder. A total of £180 million was invested to bring the new systems to market. Up to 1998 this was Europe's biggest research and development collaboration.[181]

Initially PowderJect lost money because of the lead time that it takes to get products to market. Since the product results in a drug therapy, each product has to be tested through clinical trials. For example, one of the earliest projects for PowderJect was the development an injection method for lidocaine, a local anesthetic used by dentists as well as other medical practitioners.[182] One trial on 14 adult volunteers using lidocaine as a lo-

cal anaesthetic in the mouth showed that the PowderJect injection system had no visible damage to the tissue and that there was significantly less pain than a needle.[183] In total it was necessary to complete three phases of clinical trials to test lidocaine and the third phase was not completed until 1999. In another product, the first phase of the hepatitis B clinical trial for Glaxo was not completed until late in 1998. As the time for public marketing of the injection device approached, Brian Bellhouse's daughter Emily and three others obtained a patent for the ornamental design of the injector.[184]

PowderJect Offices in Oxford[185]

The development of Brian Bellhouse's idea into PowderJect has made the Bellhouses and the Draysons wealthy families.[186] To secure their family's finances, in June of 1999 Paul and Elspeth Drayson sold 15% of their stock valued at £16.9 million. They donated £1.2 million of it to the John Radcliffe Hospital in Oxford. A week prior to the stock sale and the gift, Elspeth Drayson gave birth to her third child at the John Radcliffe Hospital. At the same time that the Drayson sold their stock, Brian Bellhouse obtained £11.3 million for some of his shares. The Draysons promised that they would not sell any more shares until the company made a profit, which was expected in 2002. Brian Bellhouse and others who sold shares at this time agreed not to sell any more shares until the year 2000. Between original stock floatation and early 2000 PowderJect stock tripled in value.[187] In 1999 the company was worth about £600 million.[188]

PowderJect Injection Device[189]

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