ENGLISH HERITAGE

WESTERN BUILDINGS
LONDON CENTRAL MARKETS
SMITHFIELD

A REPORT BY THE HISTORICAL RESEARCH & CONSERVATION SUPPORT LONDON TEAM

NBR File no: 92219
NGR: TQ 3161 8163
Reports and Papers B/013/2003

June 2003

Surveyed: March to May 2003
Reports by Joanna Smith & Jonathan Clarke
Photographs by Derek Kendall & Nigel Corrie

Historical Research and Conservation Support London Team: 23 Savile Row, London W1X 2JH
Tel: 020 7973 3000

CONTENTS

Summary

This group of four structures, comprising (in order of construction) the General Market, a triangular block, the Annexe Market and the Red House Cold Store, were built between 1879 and 1899 for the Corporation of the City of London, all to serve the London Central Markets at Smithfield. The two markets, though originally intended for other purposes, were mainly used by the meat and poultry trade until their closure in the 1990s. The Red House was built as a consequence of the introduction of refrigerated storage at Smithfield. Largely disused, its basement remains in use as a document store. The triangular block, built as offices and toilets, was shut in the 1990s.

The General Market has a squarish plot bounded by Charterhouse Street to the north, Farringdon Street to the west, West Smithfield to the south and West Poultry Avenue to the east. The building was conceived in 1879 as a fruit and vegetable market, but opened in 1883 as a fish market. It formed the third in an extraordinary linear sequence of market buildings, starting with the Meat Market of 1866-8 and followed by the Poultry Market of 1873-5 (rebuilt 1962-3), all designed by Horace Jones (1819-1887), Architect to the City of London. However, the neat geometry of the ensemble was disrupted by the construction of a further two markets. The first was built in 1886-8 to the south of the General Market for the use of the fish trade, and was known for the majority of its working life as the Annexe. This roughly triangular block, also by Jones, faces onto Snow Hill and West Smithfield. Adjoining this is the cold store building, the Red House, which was erected in 1898-99. This has its principal elevation on the east side, overlooking the triangular block of c1884-6, and a return on Smithfield Street.

A last phase of the market complex, a new fruit and vegetable market to the north of the General Market, was opened in 1892 to designs by Alexander Peebles. This building was destroyed in 1945 and, though rebuilt in 1965-8, is no longer in market use.

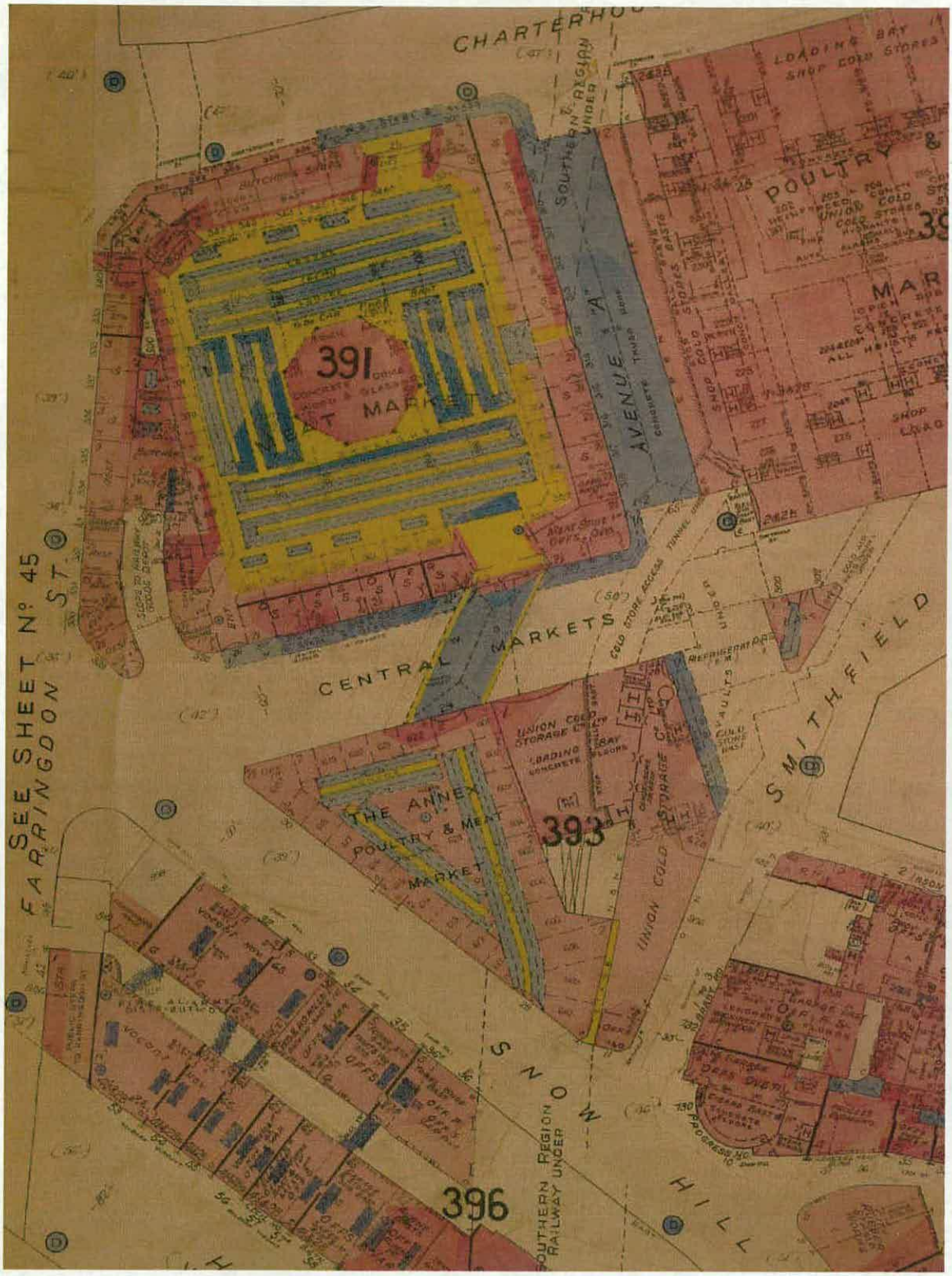


Fig. 1 - Goad Insurance plan c1956 (copyright © English Heritage).

The creation of the London Central Markets

The origins of the present arrangement of these buildings lie in the planned expansion of the market facilities at Smithfield. There had been a market place in this locality since at least the tenth century but fame and notoriety came after the re-establishment of a live cattle market here in 1638. The area's association with public executions and the often riotous Bartholomew Fair further contributed to its unsavoury reputation. The market connection might have ended in 1855, following the removal of the livecattle market to new premises on Copenhagen Fields (the Metropolitan Cattle Market), but for the decision of the Corporation of London to reuse the site at Smithfield for a dead meat market (replacing an inadequate market at Newgate, a recurrent motive in the story of the London Central Markets).[1] The general form of the new building was established in 1860, as indicated on a plan drawn up by the then City Architect J B Bunning (1802-1863), though it was his successor Jones who was responsible for the detailed design. Two factors that constrained the design were the presence of railways lines running beneath the site and the road layout, both existing and new. These considerations also had a major influence on the subsequent expansion of the market. As a consequence, one innovatory feature of the new building that was to be repeated in the later markets was the provision of railway sidings in the basement. This complicated the design process, and, when it came to the construction of the superstructure, caused delays in the erection of the new building, but it contributed to the Meat Market's commercial success.

In 1872 it was decided to enlarge the market accommodation at Smithfield with a new building dedicated to the poultry trade, thereby allowing the existing market to be given over entirely to the meat business. Behind this lay a greater purpose, in effect the centralising of certain types of market activities in one locality on a much enlarged site. The first phase of the expansion, the Poultry and Provisions Market, was completed in 1875. There was discussion about building a large new fish market at Smithfield but the Corporation instead opted for a new fruit, vegetable and flower market. This required a private Act of Parliament, The London Central Markets Act 1875, which formally renamed the growing complex in recognition of its enlarged role.

CHRONOLOGY OF THE LONDON CENTRAL MARKETS (1866-1968)

MEAT MARKET	POULTRY MARKET	GENERAL MARKET	ANNEXE	FISH, FRUIT & VEGETABLE MARKET
1866-8 built as meat & poultry market				
	1873-5 built as poultry & provision market			
		1879-83 conceived as fruit & vegetable market but opened as fish market		
		1889 converted to meat trade, renamed General Market	**1886-8** built as fish market	
				1892 built as fruit & vegetable market
			1898-9 converted to meat trade, renamed Annexe	**1897** modified for fish market
		1941 damaged by bomb		**1945** destroyed by rocket
	1958 destroyed by fire	**1953-4** partly rebuilt		
	1962-3 rebuilt			**1965-8** rebuilt with office/ showroom above

If centralisation was one motive behind the expansion others included rationalisation and modernisation. The 1875 Act provided for the closure of Farringdon Market, opened for the sale of fruit and vegetables in 1830 and long considered inadequate for its purpose. Once closed the site, only a short distance to the south west of Smithfield off Farringdon Street, would be available for redevelopment. Work on the substructure of the third market building, then called the London Central Fruit and Vegetable Market but later to become the General Market, was begun in 1879 and its design was finalised soon after.[2] The building contractors were J Mowlem & Co and the ironwork was supplied by Rownson, Drew & Co. Once work on the basement was sufficiently advanced the foundation stone was laid on the 19th March 1880. Before work could be completed the Corporation had been forced to revise its intentions, prompted by problems with Billingsgate Fish Market. Though enlarged by Jones in 1874-7, the location of the latter was far from ideal, road access being poor, and there being no rail link. In 1881 the decision was made to appropriate the new building at Smithfield for use as an 'inland' fish market. This required another Act of Parliament, the Metropolitan Markets (Fish etc) Act 1882, before the London Central Fish Market, as the building then became, could be officially opened on 10th May 1883.

The 1882 Act had granted Farringdon Market a temporary reprieve from closure but action was still required. In 1885 the Corporation decided to build a fourth market at Smithfield, on the triangular plot of land to the south of the Fish Market, tentatively assigned for use as a flower market in the 1870s. This was now to be a new fish market and the building currently serving that function returned to its original purpose - a fruit and vegetable market - perhaps because it had failed to flourish. On the 13th December 1886 the foundation stone was laid and on the 7th November 1888 the replacement London Central Fish Market was opened. The contractor for this building was Mark Gentry. Just as this was nearing completion a fifth market was approved for a site on the north side of Charterhouse Street and fronting onto Farringdon Road. The new building, the London Central Fruit and Vegetable Market, which opened in 1892 was designed by Jones's successor as City Architect Alexander Peebles (1840–1891). This finally enabled the closure of Farringdon Market. Meanwhile, the old Fish Market was converted for the meat and poultry trade, necessitating some alterations to its internal arrangements in 1889, and renamed the General

Fig. 2 - Early view of the General Market taken from the south west. (BB77/6541, ©Crowncopyright.NMR)

Market. The following year its basement underwent some modifications prior to the construction of the fifth market, creating an extensive area that extended from Snow Hill in the south to the (now demolished) goods depot south of Farringdon Station. In the mid 1890s it was decided to transfer the fish trade entirely to the Peebles building and, after the interior was modified in 1897, it reopened as the London Central Fish, Fruit and Vegetable Market. In 1898-9 the Fish Market was modified for use by the colonial meat traders and was known henceforth as the Annexe. With this final revision the London Central Markets, after an expenditure of £1,794,000 on new buildings, reached its enduring form.[3]

While the creation of the market complex at Smithfield was an ambitious undertaking, it needs to be seen as part of an even greater programme of market improvements by the Corporation in the second half of the 19th century. Necessitated by the rapid growth of the metropolis, the modernisation and expansion of the markets was to some extent forced upon the Corporation, eager to retain its dominance over (and income from) market activity in central London. Better laid-out and more status-conscious buildings, with higher standards of accommodation and better transport links, were what was required. Between 1849 and 1871 the meat trade was revolutionised by the construction of a live cattle market in Islington, the dead meat market at Smithfield and the creation of a foreign meat market at Deptford. Attention then turned to Billingsgate Fish Market, extended in 1874-7, followed by the construction of a general market at Leadenhall in 1881-2. The cost of these works for the City was substantial, with nearly three million pounds spent on new market buildings between 1849 and 1883.[4]

This extraordinary programme of work fell largely within Jones's tenure as City Architect; between 1864 and 1887 he designed a total of seven markets, as well as additions to the cattle market at Islington. His experience with the building type was therefore considerable and it is perhaps for his work at Smithfield and Billingsgate (along side Tower Bridge) that he is now best known.

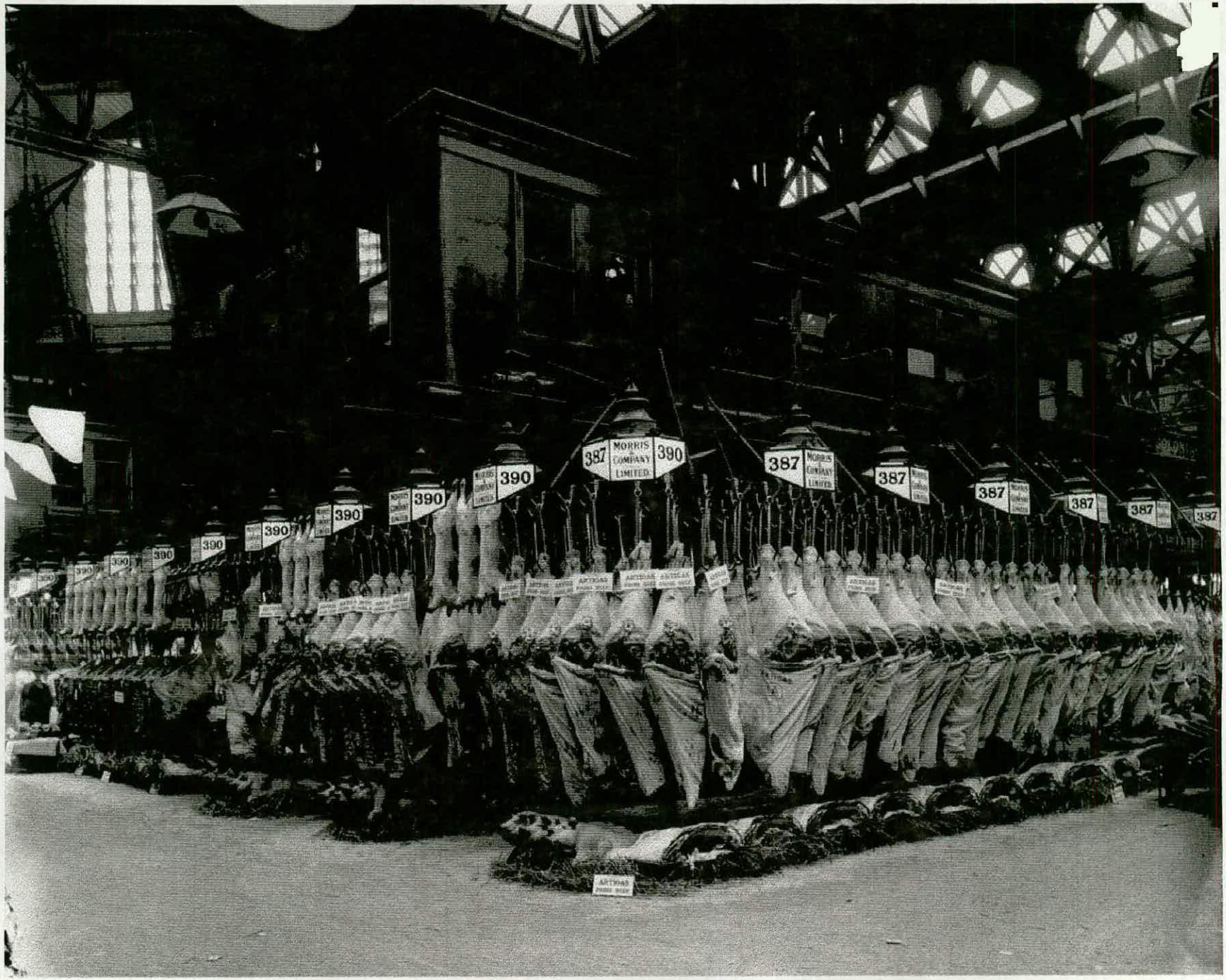


Fig. 3 - Interior of General Market looking showing part of the central area and original dome taken in 1921. (©Crowncopyright.NMR)

The later history of the London Central Markets

After the vagaries of the late 19th century the complex settled after 1900 into its role as the largest wholesale meat market in the country (ten acres in extent with six and a half acres covered by buildings), with additional provision limited to a single market building. The rapid absorption of the General and Annexe Markets into the meat and poultry trade is indicative of a thriving business. From the early 1880s this included the new frozen-meat trade. The earliest imports of chilled meat were from the USA in 1875 overtaken in 1880 by frozen meat from the Antipodes and South America, necessitating the construction of specialist handling facilities. The first British cold store was opened in 1877 in the vaults under Cannon Street railway station, followed by the construction of cold-air chambers in the vaults at the Victoria and the South West-India Docks in the early 1880s. These structures were experimental in design and relatively small in scale although by the mid 1880s larger dock-side cold stores were under construction.

The first cold stores at Smithfield seem to have followed a similar pattern of development. In 1884-7 the vaulted basements of the Poultry Market were converted to refrigerated storage by the builders Dove Brothers in what seems to have been the first substantial cold store at the London Central Markets. Steam-powered refrigerating engines were located under the roadway to the south of the building and two steam boilers were placed in vaults slightly south-west of the market. Access to these vaults was from Snow Hill via a ramp that ran parallel to King Street (now Smithfield Street).[5] An 80ft chimney stack was constructed in 1884 to serve the steam boilers. This formed part of the triangular block, which contained toilets and offices, and was also provided with three tall chimney stacks that may have served as additional vents. It seems likely that that the block was built at the same time though the documentary evidence is inconclusive.[6]

In 1898 the Corporation began construction of a new cold store building over the entrance ramp on King Street, on a site partly separated from the adjoining Annexe Market by the uncovered Metropolitan Railway lines. Built by W H Wagstaff & Sons, the Red House - as it was commonly known - was completed by 1900.[7] It was designed in two sections of different heights and functionally it is likely to have followed the usual arrangement, with insulated refridgeration chambers on its various levels,

maintained by boilers, engines and other machinery in the basement. The building had a delivery area and offices on the ground floor along with lifts for moving goods around the building.[8] The first occupant was the Central Markets Cold Storage Company (formed in the 1898 as the Smithfield Markets Cold Storage Company). In 1908 the building was occupied by Austral Limited (Refrigeration) and Imperial Food Supplies, two firms whose names readily evoke the character of the frozen-meat trade. However, for most of its working history the building was associated with Union Cold Storage Company, founded in Liverpool in 1897 by Mr Vestey. This firm still exists, part of the huge Vestey Group meat empire which includes such familiar names as Dewhurst and Weddle, whose headquarters were for many years on West Smithfield.

The construction of prominent cold store buildings seems to have taken off in the mid 1890s with the greatest concentration being in the docks and along the river and a significant group at Smithfield. One of the earliest seems to have been the London and India Docks (later Port of London Authority West Smithfield) Cold Store at 11-35 St Johns Street (built 1894-6, demolished 1968). Many cold stores were located on Charterhouse Street, surviving examples including the Central Markets Cold Storage building, 51-3 Charterhouse Street (1899, C. Stanley Peach for J Van den Bergh); cold storage warehouses, 111 Charterhouse Street (1900 A H Mackmurdo); the Port of London Cold Store, 47-49 Charterhouse Street (1914 T H Smith) and the Metropolitan Cold Store, 77a Charterhouse Street (1923, Samuel Yeo). However, the Red House slightly predates all of these and is therefore the oldest standing cold store at Smithfield.

The early decades of the 20th century saw the consolidation of the London Central Markets, as firms associated with all aspects of the meat trade spread over the surrounding streets. There were only minor alterations to the market buildings in these years, most noticeably the creation of a covered link between the General Market and the Annexe around 1900 (Figure 6), and the addition of canopies to the former building and the Red House in the interwar years. By contrast the mid 20th century witnessed huge changes to the complex, largely the consequence of wartime bomb damage and a serious fire. On the 11th May 1941 the General Market was hit, destroying the north-east corner of the building and damaging the roof. Worse followed

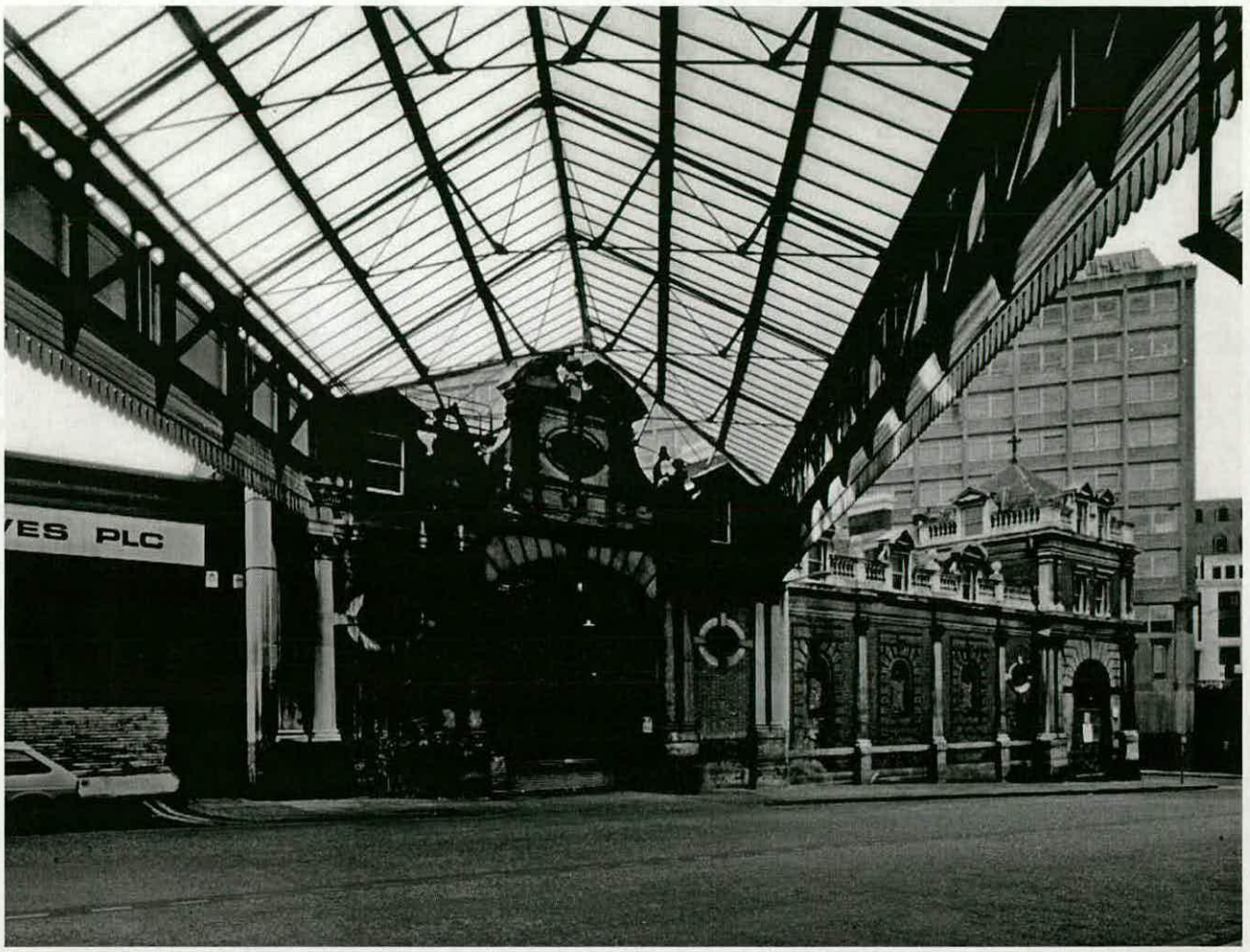


Fig. 4 – Annexe, West Smithfield elevation (A87044, copyright © English Heritage).

when the Fish, Fruit and Vegetable Market was razed to the ground by a rocket on the 8th March 1945, with great loss of life. The Poultry Market was destroyed by fire on the 23rd January 1958. Plans for the reinstatement and repair of the General Market were drawn up in 1948-9 by the City Surveyor George Halliday and the work was carried out in 1953-4. This involved the replacement of the building's most picturesque elements, a dominating tower at the north-east corner and a central dome (a smaller dome on the south-west corner was not replaced). The Fish Fruit and Vegetable Market was re-established in temporary form until the site was redeveloped in 1965-8 with a two-storey market in a podium block and seven-storey speculative office/showroom block (Caxton House) above. This building was a collaborative effort by Robert Walker, City Surveyor, and R. Seifert and Partners. The Poultry Market was rebuilt in 1962-3 in a lively and unashamedly contemporary idiom to the designs of T P Bennett and Sons. At the same time Bennett also designed a loading bay to adjoin the west side of the Red House over the railway lines, providing additional lifts to accommodate delivery by road. This addition was prompted by the cessation of railway deliveries to the markets in the early 1960s.

The shift from rail to road had an equivalent impact on the market buildings at Smithfield. In 1968 it was decided to convert the basements of the Meat Market, the General Market and Annexe into car parks, which was carried out in 1970.[9] Nonetheless market trade declined in the following decade. This, along with other factors such as issues of maintenance and modernisation, prompted a reconsideration of the future of the whole complex in the 1980s. The Corporation considered the closure and redevelopment of the Poultry, General and Annexe Markets to fund a refurbishment of the Meat market but in 1987 a modest revival seems to have granted the buildings a reprieve. However, the need for improvements remained, made all the more pressing by new European Community food hygiene laws governing the transport, storage and sale of meat that came into force in 1993. In the event, a £70 million programme of works to the Meat Market was carried out from 1993-6, funded partly by increased market rents. At this time the market halls of the unmodernised General Market and Annexe effectively ceased to function, though outer shop units of the General Market do remain in use. The future of the London Central Markets has again recently become the subject of debate after the publication of a paper in 2002 from the Depart-

ment for Environment, Food and Rural Affairs and the Corporation of London proposing its total closure.

By the early 1980s the Red House, along with the other Smithfield cold stores, has been rendered obsolete by the introduction of refrigerated lorries. The basement of the building is now used for document storage but the above-ground structure has decayed to the extent of requiring a temporary steel structure for support. The triangular block, which had weighing platforms in the roads to either side of the office in the early 20th century, was closed in the mid-to-late 1990s.

Planning, form and design

The main advantages of the site at Smithfield for an enlarged market were twofold, it was bisected by the London Dover and Chatham Railway's lines, and it had good road connections, both of which allowed for greatly enhanced access and distribution. In 1866 the London Dover & Chatham Railway had been extended northwards to Farringdon Street Station and linked to the Metropolitan Railway Moorgate extension that passed beneath the Meat Market. This allowed the Corporation to repeat the arrangement of the earlier market, placing the hall directly over the railway sidings. Ultimately a unified basement area was constructed under the trio of western market buildings. The surrounding street pattern, arising from Victorian improvements to a basically medieval layout, included two of the major new metropolitan thoroughfares, Farringdon Road, built in 1845-6 and the Holborn Viaduct, completed in 1869. The site also benefitted from a rationalisation of certain roadways carried out for the Viaduct and the initial phases of the Market, most especially Charterhouse Street and Snow Hill. Furthermore, when expansion was approved in 1872 large areas of land adjoining the Meat Market and Farringdon Road that had been cleared for the various infrastructure developments still lay unused.

However, these transport improvements imposed design constraints on the new buildings, determining their plot shapes and adding complexity to the structural arrangements (see accompanying report). Other factors to be contended with included the marked fall of the land towards Farringdon Road (from the valley of the River Fleet). This was problematic because of the intention to have a continuous level through the markets, with the Meat, Poultry and General Markets connected along a

central roadway. Furthermore the alignment of Farringdon Road precluded a strictly rectangular building. Jones's practical solution for the General Market was to break the building into three components. These were a basement, a square market hall raised at the east side so as to be on the same level as the other markets, and a projecting arm of shops along Farringdon Road with the access roadway to the basement tucked behind (Figure 6).

For the first phase of the market expansion a consistent style was imposed, vaguely defined by Jones when describing the Meat Market as 'that generally understood by the term Italian, but of a type more nearly allied to the Renaissance architecture of France than the more severe Palladian school'.[10] With the General Market this consistency began to break down, it being given a more explicitly French treatment than its predecessors, with clear echoes of Jones's then newly completed Billingsgate Market. The key features of the Meat and Poultry Markets were the corner towers and pedimented gateways. The awkward site meant that the General Market had to vary from this model with a single dominating tower set aslant the north-east corner and off-centred gateways. This tower formed one end of an impressive sequence of five towers that punctuated the skyline of Charterhouse Street and proclaimed the Corporation's great ensemble of market buildings. Unlike the previous markets the General Market had an ornate central dome and, because the road to the basement precluded anything more substantial, a small spire enlivening the south-west corner (Figure 2). Because the General Market was provided with 41 shop units fronting onto the streets on all sides it could not repeat the external arrangement of its predecessors, which were characterised by long lengths of arcaded recesses. The building's preponderance of red brick over Portland-stone dressing was a reversal of the arrangement with the earlier markets. This, and the slight diminution in the level of decoration, reflect a more economical approach to the later building by the Corporation. The trend towards less ornate treatment was made explicit in Peebles's Fruit and Vegetable Market, given only modest brick frontages with minimal stone dressing.

With the Annexe the style varied yet again, being rather more Italian that French Renaissance in character. However, the handling of the elevations echoes the earlier market buildings, with arcaded walls, ornamental ventilation grilles and pedimented

Fig. 5 London Central Markets, view along Charterhouse Street (BB87/7216, ©Crowncopyright.NMR)

gateways. The Red House has a similar arrangement of pilasters and blind windows enlivening what would otherwise be a large expanse of uninterrupted brickwork, windows usually being an unnecessary feature for a cold store. This treatment is seen to greatest effect with its towering two-storey east façade. Even the modestly treated triangular block has three tall stone circular chimney stacks, though its dominating feature - an 80ft chimney stack - has been removed. The classical vocabulary and red brick and stone dressings used for all of these buildings provide unity through the group. Given the difficulties of the site, the relatively small scale of the buildings and the variety of functions they served a more unified grouping was probably never achievable here. Instead the buildings rely on a contrast of massing, irregular forms and differing, though broadly sympathetic, styles for their visual interest and impact.

Mid-20th-century changes to the London Central Markets significantly changed the visual character of the complex (Figure 5). The Poultry Market and Fish, Fruit and Vegetable Market have been rebuilt, the latter indistinguishable from an office block and no longer in use, and major elements of the General Market have been replaced. While the rebuilding of the north-east corner and tower of the General Market was necessitated by the wartime damage the replacement of the dome and removal of the smaller tower, both still standing in 1946, seems to have been done for the sake of consistency and ease of maintenance. With the replacement tower and dome there was no attempt by Halliday to reproduce the original style, though the simplified replacements made a less radical disruption to the original stylistic unity of the ensemble than the rebuilt Poultry Market. Likewise, there has also been considerable redevelopment around the market though some continuity is provided by Holborn Viaduct and the Cold Stores and other market-related buildings on Charterhouse Street. Furthermore, the London Central Markets still hold their own in terms of townscape and character. They are also the last vestige of the City's great market building programme still functioning as originally intended.

The later markets by Jones also differ from the first buildings in layout. The Meat and Poultry Markets were essentially parallelograms quartered by roads whereas the western structures have central island blocks with stalls around the perimeter, an arrangement partly dictated by the exigencies of the sites. With the General Market the original intention was to have an open central area for temporary pitching stalls. Ac-

LONDON CENTRAL FRUIT AND VEGETABLE MARKET.—*Plan.*

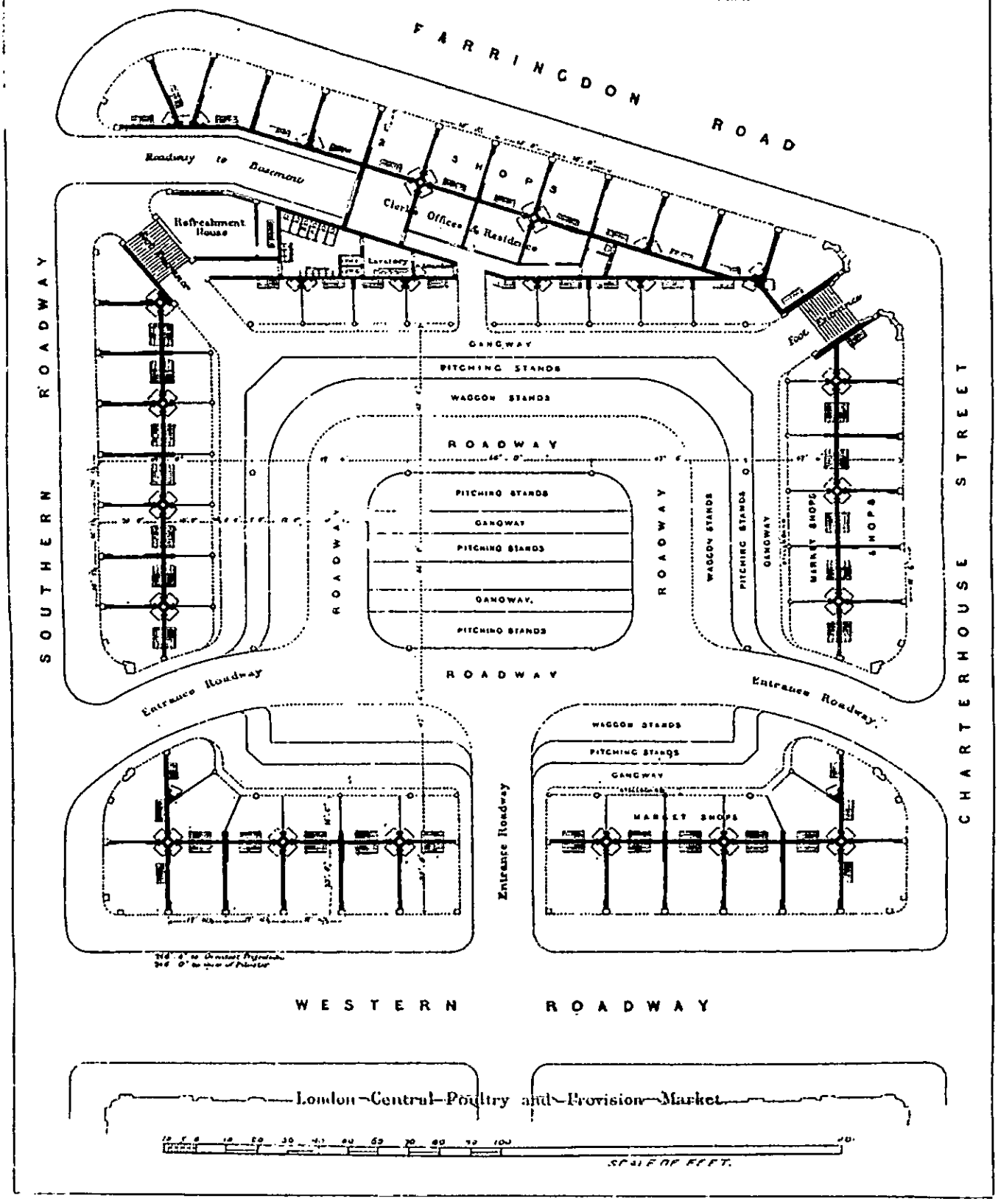


Fig. 6 – Plan of the General Market (not quite as built).

commodating such an arrangement was a key factor in the structural design of the building, an especially complex matter because of what lay beneath: 'as the lines of the upper market do not follow those of the substructure, the arrangement of plan has been a work of considerable delicacy, further complicated by the necessity to suit the railway arrangements'.[11] Jones had faced similar problems with the Meat and Poultry Markets and equivalent difficulties at Billingsgate, so had ample experience in dealing with these demands.[12]

One aspect of market design to which Jones paid particular attention was the roofs. For the Meat Market he developed what he described as 'an adaptation of the mansard principle' combining glazing and louvres to keep the building ventilated and lit. A similar approach was intended for the market hall of the General Market, with two great roofs similar to those over the Central Roadway in the Meat Market to either side of the dome. These were not built, presumably on grounds of cost. Instead a simpler method was adopted with rows of narrower roofs, something between a mansard and a pitched roof, partly glazed with louvred vents to the ridges. These served the same purposes, including the prevention of extremes of heat and rain, snow or wind getting into the market hall. Jones always preferred to use a mixture of timber and metal for his market roofs, an approach that had the support of the architect Charles Fowler, son of the noted market specialist, who was of the opinion that 'iron was the wrong material to be largely used in market construction'.[13]

Building Descriptions

The General Market

The exterior of the building is predominantly of two storeys. It is built of red Fareham bricks with Portland stone dressings in a loosely French Renaissance style in keeping with the earlier market buildings at Smithfield. It has frontages to all four sides, consistently treated throughout, though each façade varies slightly, with the greatest decoration reserved for the entrances.

There are ground floor shops to all sides, some fully glazed, separated by square cast-iron columns with classically detailed pilasters to the front. This feature is carried through the upper storey by pilasters with foliate capitals culminating in urn finials above the cornice, all of stone. Rising from the cornice band are oval-shaped dormer windows, with ornamental stone surrounds and round-headed pediments. The upper storey windows have shouldered stone architraves with keystones, both types of window being copied from Jones's Billingsgate Market rather than from his Smithfield buildings. The slate-tiled mansard roof is enlivened by stone-faced chimney stacks, grouped together and set at an angle behind the apex.

The western elevation fronting onto Farringdon Street is the least altered, largely free of the shop canopies that have been added to the other façades. The centre section of the frontage is raised to three storeys, capped by a pediment embellished with a coat of arms and cornucopia decoration recalling the market's intended use for fruit and vegetables. The southern end of the building is angled back slightly and has a three-storey polygonal 'tower' at its corner. This is decorated with pilasters, fruity swags, circular windows and a balustrade, and was originally completed by an octagonal spire, replaced with a flat roof in 1953-4.

The dominating feature of the building is a four-storey five-sided tower at its north-east corner, set at an angle and back from the building line, preceded by a flight of steps. The end bays and the tower are all stone-faced, the latter adorned by a carved coat of arms and the simple raised window architraves. A continuous concrete canopy returns across the corner and covers the entrance steps. This whole arrangement dates from the 1950s. The north end of the west elevation and half of

Fig. 7 – West elevation and corner tower of General Market (B880558, copyright © English Heritage).

Fig. 8 - South elevation of General Market (B880557, copyright © English Heritage).

the north elevation were also replaced as part of the same campaign of work though, unlike the tower, the original detailing was more closely respected. The extent of the rebuilding is clearly indicated by a change in the colour of the brickwork, the simplified decoration and concrete canopies.

The north and south sides are stepped down in stages to accommodate the fall of the land towards Farringdon Street and have carriage entrances at the eastern ends. The entrance in the north elevation is little altered, set back from the building line and provided with a pedimented gable topped with a gilt pineapple finial. The gable head has a decorative panel incorporating the date 1881 above a large arched opening filled with wooden panels. On the ground floor are two pedestrian entrances with stone surrounds and flat-headed pediments. The equivalent entrance on the south elevation retains its original dated pediment, but a glass and wood canopy was inserted around 1900, linking the General Market to the Annexe. In the mid-20th-century the walls of the entrance were brought forward to be in line with the elevation.

The south elevation has a pedestrian entrance at the west end, apparently originally open at the first floor but now with a large semi-circular window and a stone balustrade.[14] Adjoining this is the entrance road to the basement. This retains wrought-iron gates with a decorated centre boss; all the building's other gates have been replaced with modern roller shutters. Spanning the steeply inclined roadway is a two-storey block, set some distance back from the main elevation, which originally housed the market offices.

The eastern elevation is almost completely obscured by a concrete roof spanning the roadway between the General and the Poultry Market, added at the time of the rebuilding of the latter in 1962-3.

Almost all of the ground floor shops, which are tall enough to accommodate a mezzanine level, have been significantly altered. Those on the west side are closest to the original arrangement though many have been amalgamated to form larger units. Some early features survive such as the mosaic entrance panel in front of Bubbs Restaurant at the south-west corner bearing the name of a firm of tailors, C H

Attneave, who rented this space from at least 1886. And at the north-east corner there is an early if not original double door with a two-level fanlight and a ventilation grille above. On the east and south sides most of the shopfronts have been in filled with brick and given vents or smaller windows. Much of the building was provided with shop canopies in the interwar years, suspended from the façade on metal rods, sections of which still remain on the north and south sides.

Functionally and spatially the building is divided into three distinct sections - a basement car park, the central market hall area and the outer shop units. The basement extends beyond the General Market building under the West Smithfield roadway and the Annexe building as far south as Snow Hill covering an impressively large, irregularly shaped area. There are two storey vaults under the outer shops fronting Farringdon Street and Charterhouse Street, and single-storey vaults under Snow Hill. The basement substructure has a piecemeal character reflecting a phased history of construction and later programmes of alteration, repair and reinforcement. The original substructure under the General Market was formed of composite iron stancheons, at least four of which were carried through to the upper market level, supporting substantial wrought-iron girders and beams and brick jack arching. A similar form of construction was used for the basement area under the Annexe. The original form of the basement has largely survived, if not all the constructional elements. However, the northern side has been rebuilt and reduced in extent, having once extended northwards under Charterhouse Street and the Fish, Fruit and Vegetable Market. A 'gunite' fireproof finish has been applied to the columns and beams, a stair-cum-fire-exit block has also been inserted and access to the railway lines on the east side, currently used for the Thameslink service, has been blocked. These alterations probably date from 1970 when the basement was converted to be a car park, at which time the railway sidings were removed.

The square-shaped market hall has shop units on its perimeter and in the central area, encircled and divided into two halves by access roadways. There are carriageway entrances on the north, south and east sides, the latter aligned with the central roadway through the Poultry and Meat Markets. At the north-east and south-west corners there are pedestrian entrances with steps leading down to the street. The two-storey market shops facing onto the market hall are open-fronted at the

Fig. 9 – Interior of the General Market, view from west showing the Phoenix columns (BB87/7248, ©Crowncopyright.NMR).

Fig. 10 – Central dome in the General Market (B880551, copyright © English Heritage).

lower level and enclosed above, with windows and loading doors to each unit. The shop units on the east and west sides were brought forward to their present positions around 1889. At the same time single-storey extensions were made to the shops on the north and south sides, simply formed of metal I-beams carried on cast-iron columns. Some of these extensions retain paired cast-iron brackets, decoratively treated, and bolted together around the columns. These brackets supported angle-shaped beams, reinforced by crossbars and upright bars that carried hooks from which the meat was suspended. When first built the shops were provided with angle fireplaces and stairs against the back walls, but some of these features have subsequently been removed. Likewise many of the individual shop fittings have gone since the closure of the market in the early 1990s.

The present arrangement of the central area is the consequence of several phases of alterations. The original intention was for a open space, with alternating rows of pitching stands and gangways, but this may have been reworked as early as 1884, the year after the market opened. Around 1889, the space gained a quartered arrangement, with four rectangular first-floor office buildings carried on cast-iron columns. In the mid- 20th-century the north-south roadway was incorporated into the ground-floor areas of the shop units by the addition of a framework of reinforced steel joists. Above the centre of the area is a shallow concrete and steel dome, added in 1953-4, though supported by the original arrangement of iron lattice girders and polygonal 'Phoenix' columns. The remainder of the market hall has rows of hipped roofs supported by wooden trusses, part glazed and part lined with boards, with raised ridges to accommodate louvres. This is essentially the original form, though renewed and repaired in the early 1950s.

The Annexe

This tall single-stored triangular-shaped building, of dark red brick with a granite plinth and Portland stone dressings, has two elevations, to West Smithfield and Snow Hill, similarly treated in an Italian Renaissance manner. The most prominent feature is a two-storey corner tower designed to exploit the fall of the land and the triangular plot for maximum effect. This has a pyramidal roof and channelled arches to either side of the ground floor, once open but now infilled. Further embellishments include a plaque commemorating the opening of the building in 1888, a pediment re-

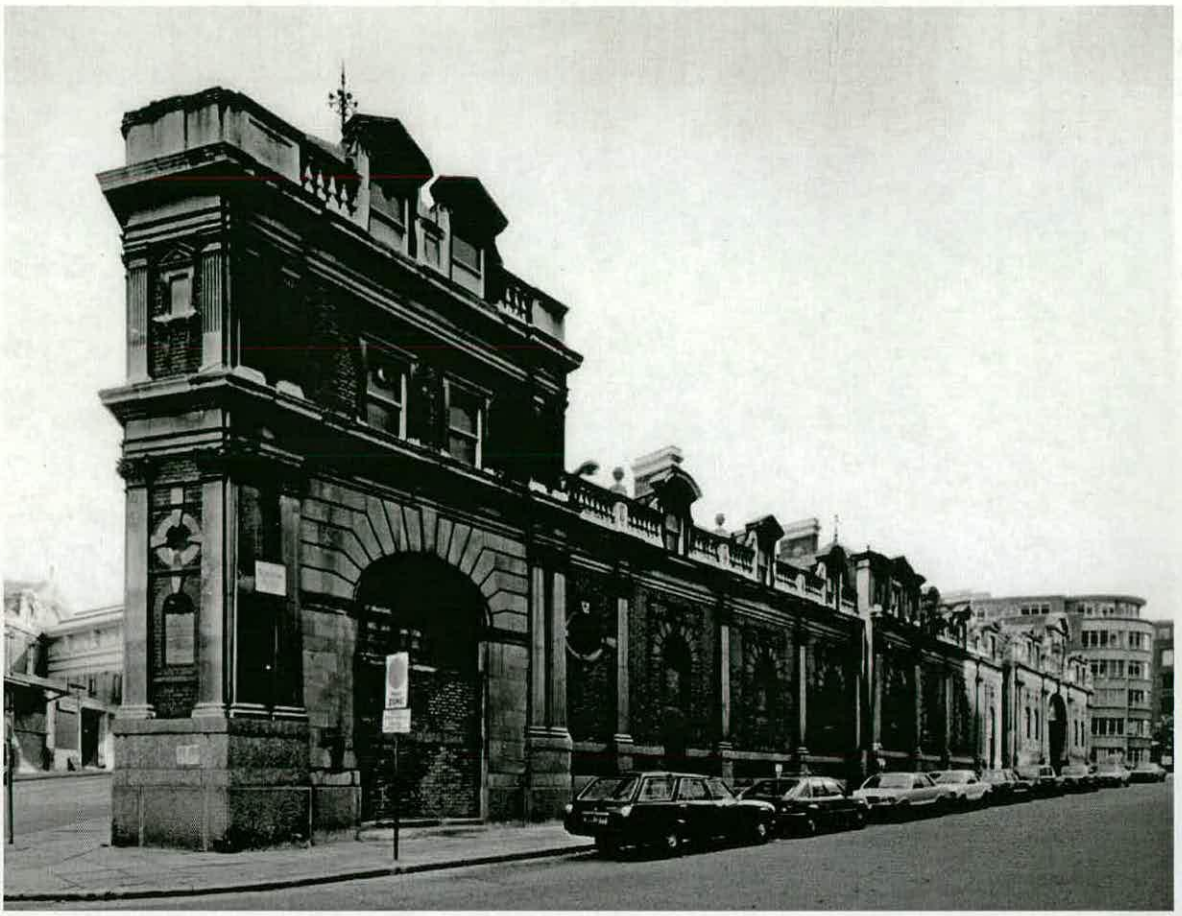


Fig. 11 – Annexe, Snow Hill elevation and corner tower (A870444, copyright © English Heritage).

Fig. 12 - Annexe, interior view to south (B880549, copyright © English Heritage).

cess to the upper storey and a foundation stone in the plinth on the north return. There are arched gateways on both elevations, both with round-headed stone pediments containing coats of arms and keystones decorated with carved fish. In addition the northern entrance has statues of boys riding dolphins flanking the pediment, this decorative scheme being an allusion to the building's original purpose as a fish market. Otherwise, the elevations are composed of blind arcades with stone pilasters. Within the arcade are arched recesses, elaborately treated with channelled brick surrounds and ornamental iron grilles to their heads. The bays flanking the north entrance have oval openings with decorative iron grilles. This is repeated in the bays adjoining the corner tower, though it was not the original arrangement. When first built these bays were open, forming pedestrian entrances that incorporated flights of steps. These openings were closed around 1898 when the adjoining bays in the base of the tower were opened to form larger pedestrian entrances, also given steps and ornamental grilles to the heads of the arches. These entrances have themselves now been blocked. An iron, glass and wood canopy of c1900 links the north entrance with the southern entrance of the General Market.

The basement of the building is described with the General Market. The interior of the triangular market hall is lined with shop units on all three sides and has a similarly shaped island block in the centre encircled by an access roadway entered from the north and south sides. The shops are open-fronted on the ground floor with an enclosed top-lit mezzanine or attic storey faced in brick with wooden sash window windows that reach almost to the roof line. The upper level is supported on square-section cast-iron columns with classical pilasters to the outer face.[15] The island block has a similar arrangement, open on the ground floor with a top-lit attic storey supported on circular cast-iron columns accessed via circular cast-iron stairs. Originally the upper level of the shops had fireplaces in the party walls and circular iron stairs, but many of these features have been removed as a consequence of amalgamation of the units. The shops were extended with a single-storey metal framework to allow for the hanging of carcases (as in the General Market) in 1898. This has been removed, with some of the columns seemingly reused as supports after the removal of party walls. Coeval alterations included the addition of a clock overlooking the market hall and the reworking of the pedestrian entrances in the north-west corner, subsequently reworked again. The island block was also modified as part of this phase

Fig. 13 – Annexe, interior taken c1921. (©Crowncopyright.NMR)

of work. An area of wood block flooring survives near the southern entrance and may remain elsewhere beneath the later tarmac covering. The roof spans over the roadways have wooden trusses that spring from the upper level of the shops, supporting glazed pitches and louvred ridge lanterns. Despite the piecemeal reworking, including the insertion of a bridge across to the centre block and two decades of disuse, the interior of the Annexe retains a considerable amount of its original form and character.

The Red House

This trapezoidal-shaped building is formed of two parts, a high two-storey range to the east and a mainly one-storey block fronting Smithfield Street with a short return on Snow Hill. The whole is built of red brick with stone dressing and has a classical treatment, derived from the adjoining market buildings (though the Poultry Market has been rebuilt in a different idiom). The east wall of the two-storey block is effectively blank, relieved by blind arcading of stone to both levels. The lower level has a high plinth, part rendered brick and part stone, with three tall narrow doorways and a segmental-headed carriage way in the northern bay. The upper level has blind circular windows and a flat-headed pediment over the centre bays. The façade retains the remnants of a canopy that had been added in the interwar years. The block has the narrowest of returns to West Smithfield and a plain eastern elevation with a large loading opening on the first floor. A single-storey extension now adjoins the eastern side of this block, built around 1963, and of functional appearance with brick piers and corrugated walls.

Extending along Smithfield Street there is a long, predominantly single-storey range. For most of its length it repeats the arcaded arrangement of the eastern block, with four irregularly spaced tall 'doorways', only the westernmost containing a smaller functioning doorway set within. The end bay is of two storeys, as is the return to Snow Hill reflecting a change in purpose as this part of the building was designed as offices rather than cold storage. On Smithfield Street the ground floor has a central doorway flanked by windows with an ornamental band above and a pair of windows to the first floor. The elevation to Snow Hill has a tall wooden doorway in a narrow end bay and pairs of windows to both storeys.

Fig. 14 – Triangular Block and the Red House from the east (BB87/7223, ©Crowncopyright.NMR).

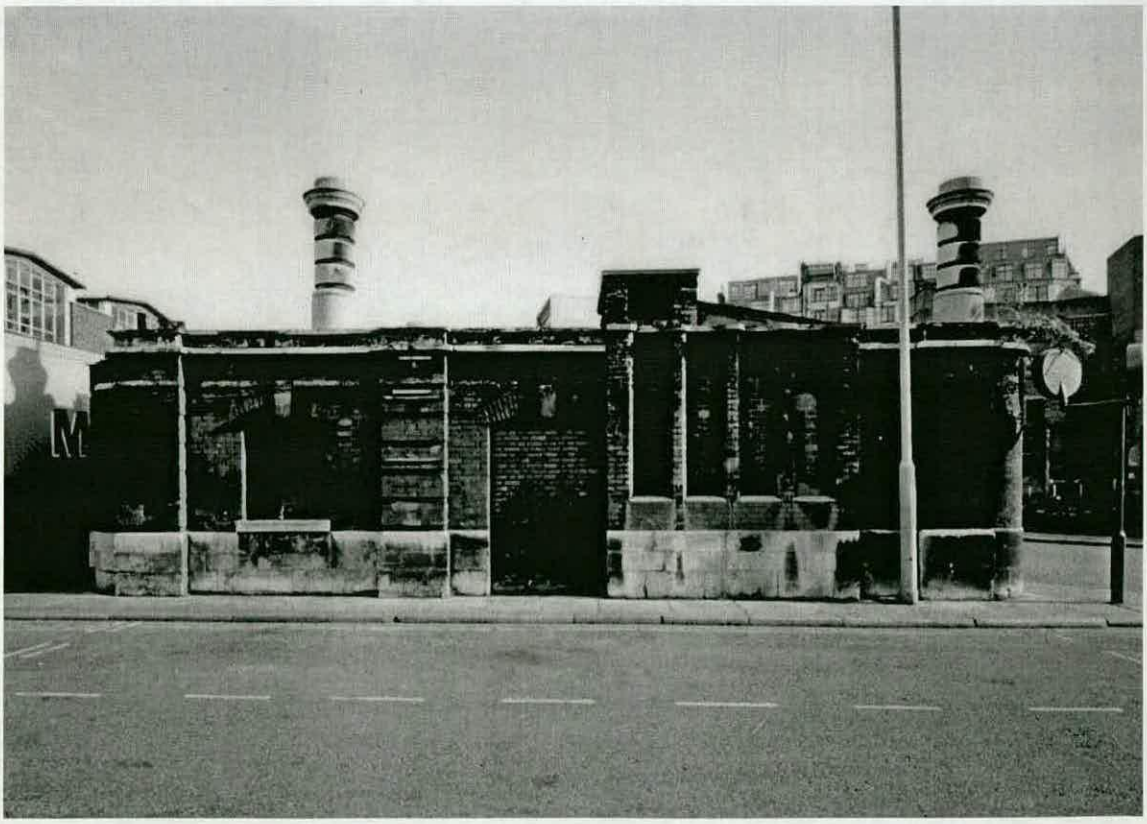


Fig. 15 – West side of triangular block incorporating base of chimney stack (A870437, copyright © English Heritage).

The Triangular Block

This low one-storey building is overlooked by the cliff-face façade of the Red House. It is a simple red-brick building with modest classical detailing including a high stone plinth, plat band and channelled brick pilasters. Its most distinguishing features are three tall circular stone chimney stacks, asymmetrically placed and now lacking their chimney pots. The entrance to the toilets on the north side is now boarded over. In the narrow north-east front is a doorway with windows to either return, indicating the position of the former office (or possibly shop), all boarded over. All other windows and doorways appear to be merely decorative, deployed simply to add interest to the building's exterior. Adjoining the west-side entrance is the remains of a large chimney stack, indicated by a break in the plat band and vertical brick ribs or mullions, subsequently reduced to the roof level.

SOURCES AND REFERENCES

Corporation of London Records Office, Architects' Plans and Surveyors' Market Plans.

Goad Insurance Maps, 1886 and 1956.

Ann Robey, 'The Metropolitan Meat and Poultry Market', unpublished report 1988, EH National Monuments Record Buildings Index File no 92219 and background notes.

Robert Thorne, 'Cold Stores in Smithfield Market', unpublished report 1988, EH Historical Research and Conservation Support file City 115.

Alan Baxter & Associates, 'The former General Market Building, Smithfield', unpublished report for Thornfield PLC, March 2003.

London Metropolitan Archives, Building Acts case file GLC/AR/BR/06/0292923; District Surveyors Returns, City of London West, MBW 1727/3.

The Builder, 12 January 1878, 34-36; 26 January 1878, 89-90; 17 January 1880, 73-4 (illus); 4 June 1881, 693; 28 April 1883, 564; 12 May 1883; 565; 2 June 1883, 760; 4 April 1885, 502; 21 November 1885, 28 May 1887, 799; 738; 12 November 1888, 357; 8 December 1888, 409.

The Building News, 19 March 1880, 355; 11 November 1881, 625; 18 May 1883, 687; 10 April 1885, 562-4; 17 June 1892, 849.

The Times, 16 November 1991, 3 April 1992, 2 December 2002.

Aslet, Clive, 'Where gutters still run red', *Country Life*, 2 February 1984, 262-264.

Donaldson, Hay Frederick, 'Cold Storage at the London and India Docks', *The Institution of Civil Engineers Proceedings Session 1896-7.*

Freeman, Jennifer, 'Sir Horace Jones 1819-1887', *Victorian Society Annual,* 1981, 45-55.

Masters, Betty, 'The City Surveyor, the City Engineer and the City Architect and Planning Officer' *Guildhall Miscellany,* vol iv, no 4, April 1973.

Bradley, S and Pesvner, N, *The Buildings of England London 1: The City of London* (London 1997), 339-340.

Bergstrom, T and Forshaw, A, *Smithfield Past and Present* (2nd edition 1990), 76-97.

Braithwaite, David, *Building in the blood: the story of the Dove Brothers of Islington 1781-1981* (London 1981), 123.

NOTES

[1] For a full account of the building of the Metropolitan Meat and Poultry Market (the present day Meat Market) see an unpublished report by Ann Robey (EH, NMR, Buildings Index file no 92219).

[2] There are several different versions of the plans for building, dated 1878 and 1880. Corporation of London Record Office. AP/LCM/GM 408- 409; AP LCM/GM5-6.

[3] *The Building News*, 17 June 1892, 849.

[4] *The Building News*, 18th May 1883, 687.

[5] Goad Insurance Map (1886), vol 11, 46. Guildhall Library.

[6] The toilet block may have been designed by Horace Jones or his Principal Clerk Andrew Murray rather than by the engineers of the Commissioners of Sewers for the City of London who were usually responsible for such buildings. In 1897 the Corporation of London took over the functions of the Commission and its Surveyor and Engineer, David James Ross, became the City Engineer.

[7] Possibly designed by the City Surveyor, Andrew Murray, or the City Engineer, David James Ross.

[8] H F Donaldson 'Cold Storage at the London and India Docks' in *The Institution of Civil Engineers Proceedings Session 1896-7.*

[9] The new Fish Fruit and Vegetable Market was designed with a lorry park on the second floor.

[10] *The Builder*, 12th Jan 1878, 35.

[11] *The Building News*, May 27th 1881 606.

[12] At Billingsgate Market Jones used the same type of lattice trusses to achieve uninterrupted space.

[13] *The Builder*, 26th January 1878, 90.

[14] This is in a slightly different position from that indicated on a published plan. *The Builder*, Jan 17th 1880, 73.

[15] These were manufactured by Andrew Handyside and Company.

THE STRUCTURAL DESIGN OF THE GENERAL MARKET

Summary

Smithfield General Market (1879-83) is a building of substantial engineering interest. For this reason key features of its design and construction are considered separately here. Unlike the great majority of British market halls, it used a two-way spanning framework, composed entirely of wrought iron, to carry its roof. This framework was conceived and erected as a self-supporting structure, its strength and stability dependent on the careful engineering of the column-girder connections. The most noteworthy aspect of the frame is the Phoenix columns, of a prefabricated hollow-circular section, and built up from four, six or eight arc segments (like straight barrel staves) riveted together through their flanges. Invented in 1862 in the USA, and of great significance in the history of construction there (it enjoyed extensive use in the first generation of iron-framed skyscrapers), the presence of Phoenix columns in Smithfield is remarkable, for the form found little popularity in Britain. Other features of significance include the considered use of laminated timber for the roof trusses in preference to iron, and the adroit structural means by which Horace Jones reconciled the differing functional demands of a ground-floor market hall with those of a subterranean railway goods station.

Ground Floor Market Hall

The two most common methods of roof construction used in the building of 19th-century market halls were the traditional trussed roof, and the more structurally ambitious arched roof.[1] Horace Jones's take on the problem posed at Smithfield General Market (1879-83) was unusual, yet highly rational. In both of these systems, long-span roof trusses or arched ribs, supported on opposing ranks of cast-iron columns, typically spanned in one (longitudinal) direction, with secondary roof systems between. To achieve greater width, 'nave-and-aisle' or multiple nave plans were usually invoked. At Smithfield, faced with the need to roof an area that was near square on plan, Jones departed from convention by introducing a modular two-way spanning framework that could carry smaller, cost-effective secondary roof systems running in both directions, and which itself was carried on a minimum

number of point supports (columns) whose placement meshed well with internal planning (Figure 16). Since the area was square, it made more sense to span the trusses in both directions at once, making the two interactive - rigid in two mutually perpendicular planes. Such an approach had been most famously pioneered by Charles Fox in the Crystal Palace (1851), designed around a gridded, 24ft-square module that was the same in both directions, and which could be added to equally in both directions. That structure has been fêted for embodying 'a peculiar brand of three-dimensional technological thinking',[2] a mode of thinking also evident in Smithfield General Market, albeit on a less ambitious scale. Alternative designs prepared in Jones's office show that he did consider more usual approaches, involving cast-iron columns and wide-span iron trusses, but the Committee did not select these, probably for reasons of cost and fitness-to-purpose.[3] In this sense, Jones made structural and functional virtue out of economic necessity.

The single-storey skeleton frame of the first floor of the General Market is a rigid assembly of standardised prefabricated iron components; principally wrought-iron lattice girders arranged in a series of contiguous rectangles, supported at their corners by 16 tall, built-up columns of the same metal. Characterised by diagonal bracing of 'St Andrew's Cross' configuration,[4] the lattice girders are of uniform depth (4ft 7in.), but are employed in spans of 56ft and 47½ft, in accordance with the column spacing. This column spacing was ordered around four innermost columns, supporting a central domed roof of 56ft span, with flanking columns placed at the corners of eight notional rectangles around this central square; in effect a central 56ft-square quad bordered by four rectangles of 56ft x 47½ft and cornered by four squares of 47½ft x 47½ft (Fig. 6). Clearly a standard 47½ft or 56ft-square module throughout would have had greater efficacy, requiring only one length of lattice girders, but the dimensions of the grid were a considered reconciliation between the need for a large column-free area in the centre for pitching stands, the need to avoid columns in the 18ft-wide roadway surrounding it and in the perimeter gangway, and the geometry and total area of available land.

Fig. 16 – The modular two-way spanning framework of lattice girders and Phoenix columns, supporting laminated-timber roof trusses (DP001752, copyright ©English Heritage).

The framework was conceived and erected as a self-supporting structure, its strength and stability dependent on the careful engineering of the column-girder connections. The cast-iron bolting heads surmounting the column shaft were especially designed with this in mind, the weight of the girders taken by sturdy brackets, with rigidity ensured by the facility the heads offered for bolting the ends of the beams through the full depth of the web (Figure 17). Perhaps for reasons of additional safety, the framework is tied in a few places to the enclosing masonry superstructure by additional perimeter lattice girders whose ends are seated in the brickwork. The framework of primary girders running in both directions was designed to provide a sufficiently strong foundation for the secondary roofing system, including the ability to withstand wind pressures. Economy dictating that it should be made up of eight narrow hipped roof spans (four long and four short), further lattice girders subdivide the framework, bisecting each of the rectangular modules and providing footings for the narrow-span roof trusses. Formed especially from vertically laminated timber in preference to iron, and with elegant, arched lower chords, these *c.*24ft-wide trusses spring from the lower flanges of the lattice girders, and carry the partially glazed, louvred roofs - a scaled-down version of Jones's adapted 'mansard principle'.[5] The use of laminated timber, first introduced in the 16th century, was resurgent in the mid-to-late 19th century largely because it was lightweight, inexpensive, prefabricated and quick to assemble.[6] Unlike other market hall designers, Jones seems to have been aware of these advantages; his buildings at Smithfield appear to be the only British examples to exploit the technique.[7] At the centre of the building, the original lattice girders carry the weight of the reinforced-concrete saucer dome added in 1953-4 to replace the former lofty timber-and-iron-framed octagonal dome, testament to the structural integrity of the frame. To carry the original dome, additional lattice girders were introduced, spanning the corners of the 56ft-square as squinches to form an octagonal bearing surface. These too survive.

The conceptual clarity of the bi-directional rigid framework, anticipating the 'space frames' of the next century, and the application of laminated timber, are of considerable interest, but the real distinguishing feature of the market's

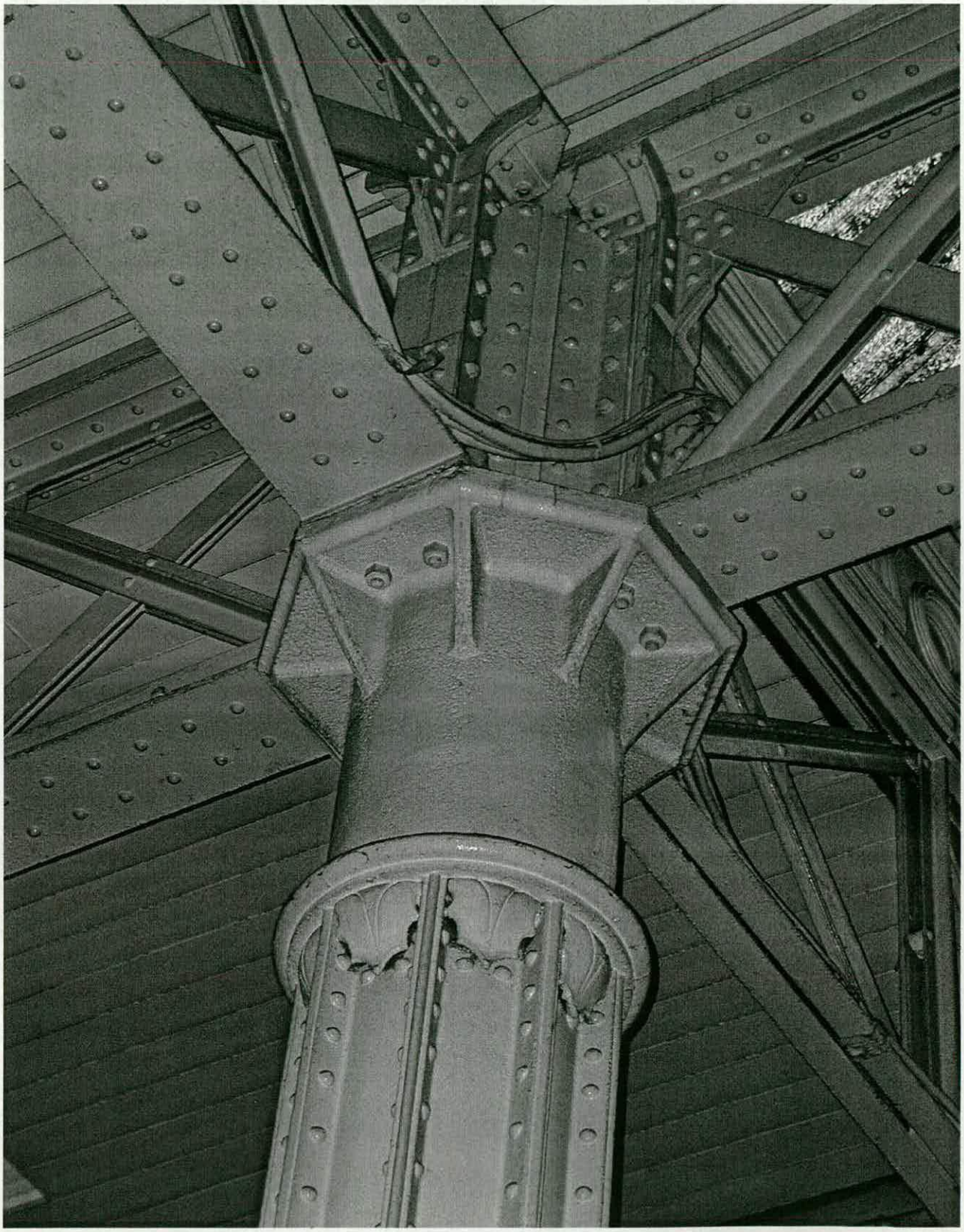


Fig. 17 – Exposed bolting head surmounting Phoenix column. The removal of foliate ornamental dress makes visible the manner in which the rigid column-beam connections were made (DP001753, Copyright © English Heritage).

engineering is its employment of Phoenix columns. Columns built up from rolled wrought-iron components were expensive and were seldom used in building's. Phoenix columns, at least in Britain, were rarer still. This appears to be one of only two buildings in the country where they survive, and much the largest, and certainly the only British market hall.[8] The low cost of traditional cast-iron columns ensured that they enjoyed continued use well into the 1900s when they were superseded by cheapening built-up steel stanchions, and we can only speculate why Jones chose to use them here. One reason is suggested by their impressive height, about 26 ft exclusive of the attached cast-iron top component.[9] The casting of long cylindrical columns was fraught with difficulties, requiring the pouring of iron into both ends of a mould with the uncertainty that the metal was properly united in the centre. For most buildings, columns were usually cast in single-storey lengths ('storey posts') – those used at Smithfield were of two-to-three storeysin height. Still, even with casting defects, cast-iron columns rarely failed, and market hall designers continued to use very long examples throughout the 19th century.[10] Perhaps Jones was excited by their novelty, their practical advantage in this particular context, and by their decorative qualities. Of their novelty to the British building scene in *c.*1881 there can be little doubt.[11] Their practical advantage in this context was that, being made from wrought iron – a ductile material – they were able to withstand heavy impact from carts or otherwise. Rownson, Drew, & Co., the structural ironwork contractors, and one of the first British companies to manufacture Phoenix columns, emphasised this in their trade catalogue, albeit in relation to the use of rolled joists as stanchions: 'In cases where ornament in not a necessary element, and the columns are exposed or liable to injury from cart wheels, & c., which would cause damage to cast iron, rolled joists will be found invaluable'.[12] Phoenix columns were stronger still, and were certainly of a more ornamental character, especially when adorned with cast-iron bases and wrought-iron foliated capitals, as at Smithfield. Here, the bases defended the column shaft from vehicles, and the foliated capitals concealed the column-beam connections (Figure 18). Aside from such applied ornament, Phoenix columns had intrinsic decorative quality, the parallel lines of rivets running up the shaft drawing the eye upwards to those on the underside of the lattice

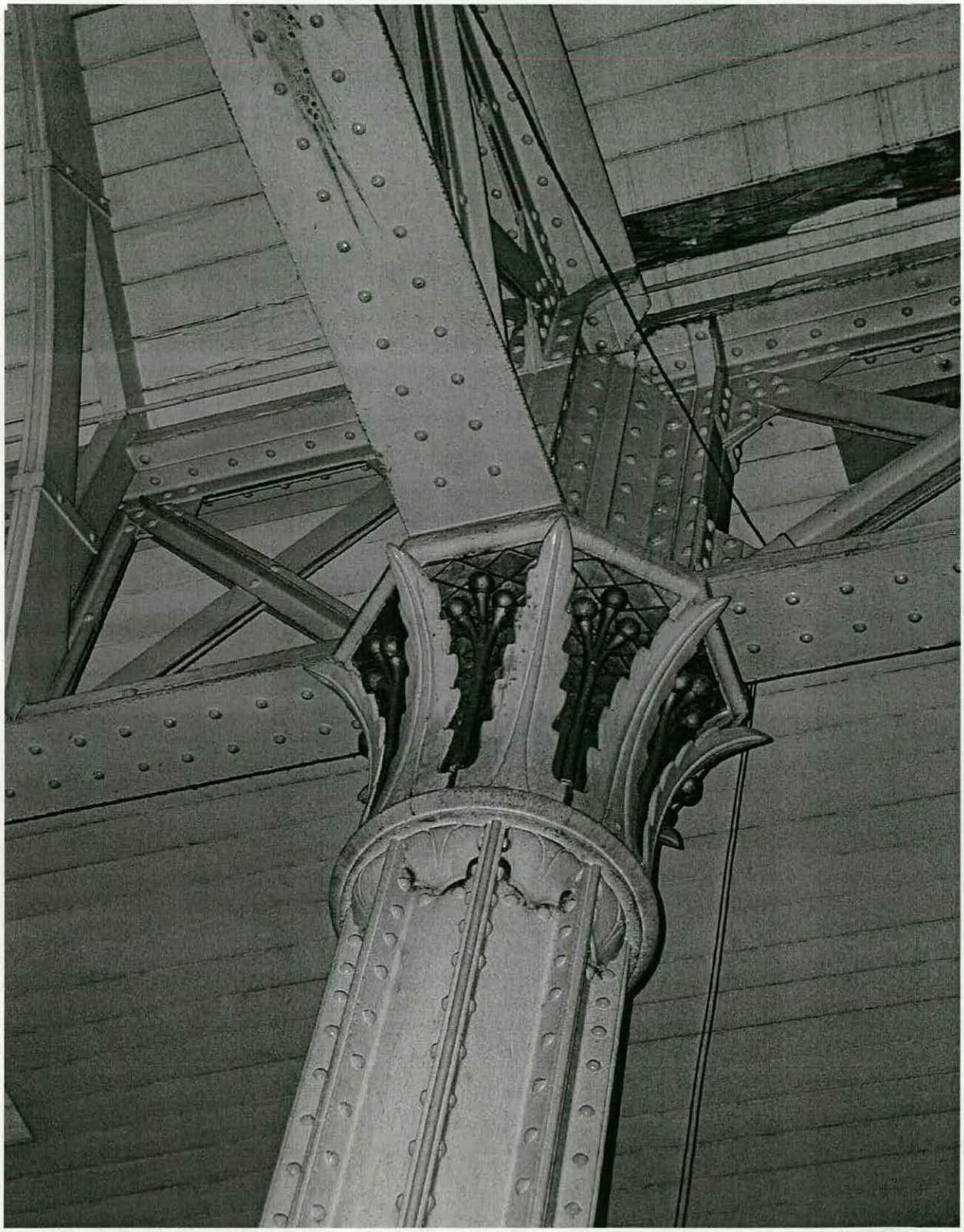


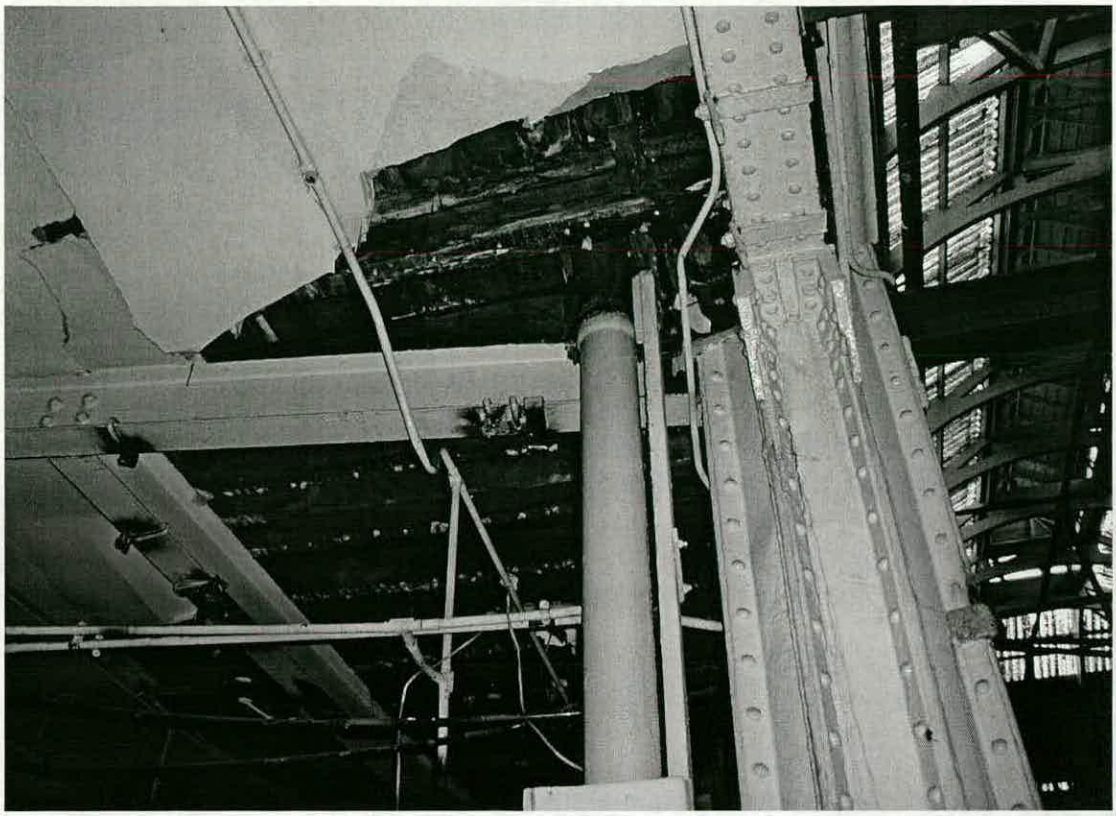
Fig 18 – Detail of Phoenix, showing filler pieces between the arc segments, and wrought-iron foliate capital (DP001754, copyright © English Heritage).

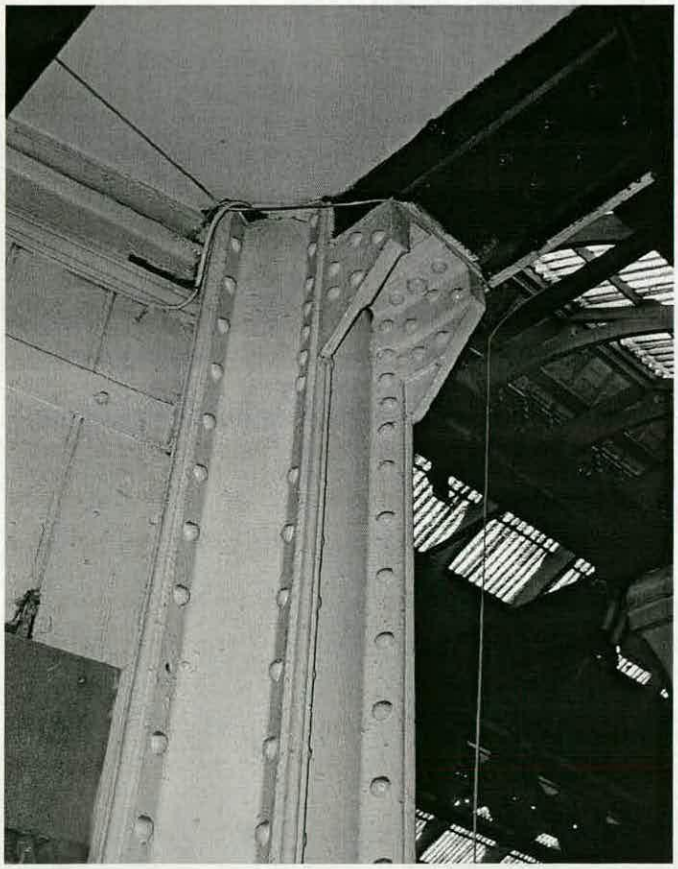
girders, alluding to the unanimity of materials in both compressive and tensile situations.

The supreme virtue of Phoenix columns was the ease with which rigid column-beam connections could be made, accomplished simply by riveting the beam to the flanges via projecting 'filler pieces' or plates. It was not until the mid-1880s that engineers in the column's native United States realised this facility, so it is not surprising that this was not exploited in the construction of the General Market (cast-iron bolting heads were used instead for this purpose). However, it is interesting that the General Market does document this technological development, for the single-storey extensions to the shops added in *c.*1889 are supported by built-up beams, carried for the most part on cast-iron columns, but in some cases resting on shelf brackets riveted to the flanges of the Phoenix columns (Figure 19 and 20). This testifies to the speed with which new constructional iron/steelwork techniques crossed the Atlantic. The rolled joists supporting the floor of the shop extensions may be steel, which would constitute an early use of the material.

Basement

One of the most difficult engineering problems Jones faced was the creation of a two-tier building that structurally reconciled the differing functional demands of a large subterranean railway goods station with those of a ground-floor market hall. The dense arrangement of supporting columns in the basement, dictated by the railway lines, could not be superimposed upwards to the market hall, because this would have conflicted with the need for spatial openness. Conversely, the structural grid of the market hall could not be applied to the basement because the distance between the columns was too great to enable a floor structure of sufficient strength, and would have interfered with the track layout and sidings. Engineering the best solution was, according to Mr Gosling from the City Architect's office, 'a work of considerable intricacy'.[13] Jones's answer was a phenomenally strong floor structure, capable of bearing the concentrated loads of the peripheral ground-floor columns, whilst maintaining the structural rhythm in the centre, where the vertical loadings were most severe. The four central columns were thus





Figs. 19 and 20 – Shelf brackets riveted directly to the flanges

of the Phoenix column– a technique similar to those

being used in contemporary American skyscrapers
(DP001755-6, Copyright © English Heritage)

brought to bear directly onto four tall stanchions in the basement, transmitting a significant proportion of the loads of the first-floor directly to the foundations.[14] Only one other Phoenix column, in the northwest corner of the market, was seemingly able to sit directly on a stanchion. The rest were carried on the girders and beams framing the non-combustible floor, or, extraordinarily, on the brick floor itself.

The 'jack-arch' floor construction of the basement conforms to that commonly used in goods sheds of the era, consisting of wrought-iron box girders spanning on one axis only, supporting shorter longitudinal I-section beams from which brick arches are turned (Figure 21). The lines of the main box girders, spaced 20 feet apart, formerly rested on wrought-iron stanchions spaced on 45ft centres. Many of the original stanchions have seemingly been replaced in the successive campaigns of alteration that began in the 1890s, although the position of the originals is largely reproduced. The density of this grid of girders and beams was such that, for the most part, the majority of the Phoenix columns were able to sit directly above the metal, but in a small number of cases, they do fall between. This was perhaps inevitable, given that the grid of the ground floor was set on a different orientation to that of the basement. In those situations, it seems likely that large concrete blocks were used as pad foundations for the columns, preventing the column base from punching through the brickwork. An unorthodox yet nimble solution, this approach had already proved its worth in the construction of the Metropolitan Poultry Market, so it seems plausible to suppose that it was used here.[15]

Perhaps the most distinctive structural feature of the basement is the careful design of the supporting wrought-iron stanchions. These were not of Phoenix form, but appear to be of box or rectangular section.[16] Averaging 29ft tall, they were designed in four classes to take maximum loadings of 170, 240, 285 and 350 tons apiece – crushingly heavy responsibilities, even by today's standards. The more expensive wrought iron was probably chosen for its ability to withstand impact from a runaway engine without shattering, but also because it could be fabricated into forms that distributed the metal most efficiently to reflect the stresses it was expected to take. Thus the columns

Fig. 21 Heavy jack-arch floor construction of the basement. Much of the structural ironwork, including the wrought-iron stanchions with flared heads, is both protected and concealed by a sprayed concrete coating (DP001757, copyright © English Heritage).

were designed with flared heads and shouldered bases, to spread the load and prevent the column from punching up through the floor, or shearing near its base. Although protected by a 'Gunite' fire-resisting casing, this feature is still readily comprehensible, distinguishing the original surviving columns from later steel ones.

Appendix: PHOENIX COLUMNS

The Phoenix column was launched on the American building scene in 1862, and over the next 30 years would enjoy a rising popularity and status as one of the most original and useful building components of the era. Today, that country's building and engineering historians accord it the same kind of reverence that we over here give to early examples of cast-iron columns, a form that the Phoenix column was designed to replace. This admiration is well founded, not least for the profound and widespread impact it had on urban structures, including the first generation of iron-framed skyscrapers.

The invention of the Phoenix column has been credited to Samuel J. Reeves of the Phoenix Iron Company at Phoenixville, Pennsylvania, who was granted a patent on it in 1862.[17] There is evidence however that the form was originally devised a year or so earlier by the Baltimore and Ohio Railroad engineer Wendell Bollman.[18] Whatever the authorship, it was the Phoenix Iron Company - the second American firm to roll iron into I-shaped beams - that began manufacturing it from the early sixties. A prefabricated wrought-iron column of hollow-circular section, it was built up from four, six or eight arc segments (like straight barrel staves) that were riveted together through their flanges. Certain of the superiority of wrought iron over cast iron, Reeves's main intention had been to design a column that was easy to roll and assemble, yet large enough to bear the heavy loads of bridges, elevated railways and high buildings. Advantages over the cast-iron column, he asserted, included greater rigidity against bending derived from the flanges (long columns had a tendency to buckle), and an ability to distribute more evenly the lateral loads brought by connecting beams over the entire section

of the column. In essence, Phoenix boasted, its column provided a maximum of strength with a minimum of weight, and, owing to the simplicity of its construction, the company claimed it was the cheapest on the market.[19] This last assertion may have been misplaced – cast-iron members were almost always cheaper to produce – but then cast iron was a heavy, brittle material that could fail without warning, with often treacherous results. In the space of a few years, the company introduced the 'Improved Phoenix Column', which incorporated full-length vertical filler pieces between the flanges of the segments, to increase the circumference (and hence the strength), and to enable connections directly to these projecting filler pieces rather than the double flanges. It is this form, first used in 1867 in support of the printing presses in the Public Ledger Building, Philadelphia, that was judiciously employed at Smithfield in 1879-81. The decorative qualities of the exposed columns of this American building were certainly appreciated by its owners, who stated:

> ... The effect produced by the projecting flanges and filling pieces is somewhat similar to that of large fluted columns and is quite ornamental. The columns are also painted, with the small round projections which mark the bolts (rivets) bronzed. The whole finish is such as is rarely, if ever, found in an underground apartment.[20]

Phoenix's objective had been to expand production of structural wrought iron in addition to its traditional mainstay, rails, and the Phoenix column was decisive in bringing about a shift in their focus from railroads to urban structures. One of its earliest architectural uses was in the interior iron framing of the four-storey Brown Brothers Bank Building, 59 Wall Street, New York (1864-5; demolished), described as the 'finest private banking house in the world'.[21] So novel was the column, that according to one of the banking firm's partners 'neither the architect nor the builder was willing to assume the responsibility, and the owners had to be content with the guarantee of the makers'.[22] But success was to come. From the late sixties onwards, the company's principal product would help transform the structural and visual character of numerous American cities, as new engineering marvels were added year by year. From a prototype elevated railway built in 1867-8 along a

half-mile of Greenwich Street, Lower Manhattan, supported on a single row of 14-foot-tall Phoenix columns, to similar, but considerably longer, one or two-legged structures in New York, Chicago and other principal cities, Phoenix columns enjoyed extensive, eye-catching use. On seeing the west side extension of The New York Metropolitan Elevated Railway, French diplomat and promoter of the Suez Canal, Viscount Ferdinand M. de Lessops (1805-1894) characterised it as one of the most audacious engineering feats. More daring still was Reeves's extraordinary suggestion of building a 1,000-foot observation tower for the 1876 Philadelphia Centennial Exposition, a diagonally braced assembly of giant Phoenix columns that was illustrated on the front cover of Scientific American.[23] It never materialised beyond a model, but two towers of a more modest 215ft were built for the exposition. The model however so captivated Gustave Eiffel that he subsequently gave tribute to Reeves for having inspired him to build his own 1,000-ft wrought-iron tower in Paris in 1889. Throughout the late 19th century huge numbers of bridges, trestles, railway stations, industrial buildings and so forth were constructed with Phoenix columns, a quantity perhaps almost matched by the number of prefabricated structures exported by the company worldwide.

But it was the important role that Phoenix columns played in the engineering of the first generation of skyscrapers that is perhaps significant. By the mid 1880s, as taller, narrower buildings arose from increasingly constricted sites, the need for wind bracing became a matter of increasing urgency. Connections for cast-iron columns had to be bolted, resulting in a less rigid assembly less able to withstand wind pressures. Whilst this could be counteracted by the use of floor height trusses, these introduced their own complications since partitions had to be introduced wherever the trusses were placed. Phoenix columns, being made of wrought iron, could be riveted, and it was this facility – unforeseen by Reeves in the early sixties – that prompted engineers to champion their use. The riveted column-beam connections of Phoenix columns were sufficiently rigid to enable simple methods of windbracing, precursors of more sophisticated systems that emerged in the 1890s when construction in steel became standard. Many high buildings were constructed with Phoenix columns in New York, including the enlarged

Equitable Building, Madison Square Garden (1886-89); the World (Pulitzer) Building (1889-90, demolished); the Union Trust Building (1889-90, demolished), all designed by George B. Post, the Commercial Cable Building (1896-97, demolished) and Dun Building (1897-99), both by Harding & Gooch'. In such tall office buildings, the columns were typically positioned in the centre and innermost parts of the buildings, where the floor loads were greatest. In Chicago, one of the most celebrated buildings to employ Phoenix columns was Adler and Sullivan's Garrick Theatre, West Randolph Street (1891-92), a combination theatre and office in which 'the most remarkable elements of the frame were the four Phoenix columns 93 feet high that carried the brick walls rising from the level of the rigging loft above the stage'.[24]

In the early 1890s, Phoenix switched from wrought iron to steel production on the open-hearth method, General Superintendent William Reeves having observed in June 1890 'In every direction our customers are calling for steel, and we must satisfy them or see them go elsewhere.'[25] Structural steel was the material of the future, and American bridge engineers were already specifying steel columns and stanchions for bridge truss members, and for the frameworks of the skyscrapers they were being called on to design. Although Phoenix began producing steel columns from 1891, the move came too late, and only a small handful of buildings, including the Hoyt Building in New York used Phoenix columns of steel. From the 1890s, structural engineers turned in droves to Z-bar and rolled 'H' steel columns, forms that facilitated better connections and more efficient distribution of loads. Almost as suddenly as it had arisen into general use, the Phoenix column disappeared from the American scene. 'But in its day', wrote historian Alan Burnham, 'it was a radical departure from existing structural forms and an imaginative solution to existing structural problems',[26] 'in a sense ... ahead of its time'.[27]

Whether by illegal imitation or licence, Phoenix columns were produced, albeit for a limited period, by British and Continental manufacturers in the late 19th century. We know this not from extant examples, but from surviving trade catalogues. Indeed, in this country, only two examples of their use in buildings[28] have come to light: the Railway Station at Redhill, Surrey

(1890s?), where rolling marks testify to Burbacher Hűtte of Germany as the manufacturer[29], and the General Market at Smithfield, where the columns were probably fabricated from Belgian rolled iron.[30] Although the trade catalogues of companies such as Dorman, Long & Co., of Middlesbrough show that Phoenix columns were produced in steel for a while in the 1890s, the more decisive and longer-lasting impact in this country was the form's generic influence on the structural design of other columns. They parented numerous variations, including octagonal and square arc sections, which were built up from splayed steel channels that had formerly been restricted to use in the trough flooring of bridges and industrial buildings. Alfred Waterhouse was one of a number of architects to pioneer the use of such very early steel columns, using them in buildings such as the National Liberal Club, and the Prudential Assurance Company Office, albeit clothed in terracotta and faience.[31]

Notes and References

[1] James Schmiechen and Kenneth Carls, *The British Market Hall: A Social and Architectural History* (Yale, 1999), p. 115.

[2] Tom F. Peters, *Building the Nineteenth Century* (MIT, 1996), p. 248. Professor Peters notes: 'Most structural designers think primarily in two dimensions, even today. They design a building in plan and cross section and create frames two-dimensionally, then stack them one behind the other to form a three-dimensional building'.

[3] Two of the section drawings show long-span wrought-iron roof trusses supported on ranks of cylindrical cast-iron trusses, with no central dome [LCM/GM 5 & GM 6]. Another depicts a central timber-framed dome, reinforced with cast-iron ribs and purlins, flanked by two aisles framed by deep, decorative cast-iron ribs of a near-identical form to those used in the Meat Market of 1866. [LCM/GM 4].

[4] This structurally efficient form, prefigured most famously in cast iron at the Crystal Palace (1851), saw widespread use in the period *c.*1860-1890, when it was almost exclusively fabricated from rolled-iron components. Such was its success that it continued to be used in steel until the 1930s.

[5] *The Builder* applauded these, noting 'The roofs are of laminated rib construction, with a range of glass louvers at the sides, affording an ample amount of light and air, with protection against sun, and with open-air ventilation and protection against rain and snow – so requisite for a market of this character'. *The Builder*, 4 June 1881, p. 693. See also p. 6.

[6] First suggested by Philibert de L'Orme (*c.*1510-70) in his earliest published work, *Nouvelles inventions pour bien bastir* (*New Inventions to Build Well*, 1561), early laminated timber consisted of short curved segments of wooden planks to pegged together side-by-side form long continuous structural ribs. Used to frame arched and domed spaces, these ribs were considered a major advance over other European timber vault construction systems. Following a period of disuse in the 17th and 18th centuries, the technique witnessed a great revival of interest in this country in the 19th-century, largely on account of the introduction of horizontally laminated ribs where planks were fastened together one above the other and shaped into curved structural members. This obviated the need to shape individually the planks beforehand, with resultant economies in both cost and time. Well known applications of this technique, which had benefited from French experimental work, include the original roof of King's Cross Station (1851-2, Lewis Cubitt architect), The German Gymnasium, St. Pancras (1866), St. Paul's Presbyterian Chapel, Millwall (1859, T.E. Knightley), but it was also used for the roofs of many other mid-to-late 19th-century buildings, including Grassington Church in Liverpool, Leeds Town Hall (1853-8, Cuthbert Brodrick architect), Hazelwell Boarding House, Cheltenham (1865-6, William Hill Knight, architect), and a number of West Yorkshire textile mills. Vertically laminated structural members were used – albeit utilising simpler joinery and connection methods than the intricate techniques used in the 16th and 17th centuries – in a smaller number of 19th-century British buildings, with the roof of the transept of the Crystal Palace perhaps being the most famous example. The technique still enjoys widespread application today, often in structurally daring ways – Pringle Richards Sharratt's winter garden in Sheffield, framed using 22 metre wide laminated larch arches, is a recent example (see *RIBA Journal*, January 2003, pp. 24-30.).

[7] Schmiechen and Carls (*op. cit.*) make no mention of laminated timber in their authoritative survey of British market halls.

[8] All examples of British Market Halls cited in Schmiechen and Carls (*op. cit.*) make exclusive use of cast-iron columns. Only one other British building incorporating (four-section) Phoenix columns – a railway station in Surrey – has come to light. See appendix.

[9] *The Building News* (27 May 1881, p. 606) notes that the lower flanges of the lattice girders were carried at a height of 28ft.

[10] Bolton Market Hall (1855-6) for example used 50ft-high columns. See Schmiechen and Carls (*op. cit.*), p. 254.

[11] Phoenix columns were certainly new to *The Builder* and *The Building News* when they carried their reports on the new Smithfield market, describing them as 'somewhat novel in construction'. 4 June 1881, p. 693 and 27 May 1881 p. 606 respectively.

[12] Rownson, Drew & Co., *Illustrated Catalogue of Constructional Iron Work* (*n.d.*, probably late 1870s/early 1880s), p. 37.

[13] *The Building News*, 27 May 1881, p. 606

[14] Alan Baxter & Associates, General Market Building and Annexe (March 2003), p. 36, para 6.3.1.

[15] ' ... when the Metropolitan Poultry Market was constructed it was desirable, for the sake of symmetry, to place a column exactly over the centre of the railway tunnel. The plan adopted by Mr. Horace Jones was to surround the brickwork of tunnel with an inch of sawdust ... and a bed of concrete 5ft. in thickness and 8ft square, was placed above it; and on this foundation the column was bedded, and has stood well.' *The Building News*, 10 April 1885, p. 564.

[16] Although concealed by 'Gunite', the sectional form of one is deducible from one of the contract drawings [LCM/GM4 408 No. 5] dated 14 October 1879.

[17] Samuel Reeves, Patent 35,582, 'Improvement in Construction of Wrought-Iron Shafts or Columns' (17 June 1862). For a reproduction of the original patent drawing, see Thomas J. Misa, *A Nation of Steel: The Making of Modern America 1865-1925* (John Hopkins University Press, 1995), p. 52.

[18] According to Condit, the same form was used for the supporting bents at a bridge erected at Havana, Cuba, about a year before the date of the Reeves patent. Carl W. Condit, *American Building: Materials & Techniques from the First Colonial Settlements to the Present* (Chicago, 1982), p. 92.

[19] Alan Burnham, 'Forgotten Engineering: The Rise and Fall of the Phoenix Column', *Architectural Record*, April 1959, p. 223.

[20] As quoted in Alan Burnham, 'Forgotten Engineering: The Rise and Fall of the Phoenix Column', *Architectural Record*, April 1959, p. 224.

[21] Mathew Hale Smith, *Twenty Years among the Bulls and Bears of Wall Street* (Hartford, 1871), p. 293, as quoted in Sarah Bradford Landau and Carl W. Condit, *Rise of the New York Skscraper 1865-1913* (Yale, 1996), p. 55.

[22] John Crosby Brown, A Hundred Years of Merchant Banking (New York, 1909), p. 228, as quoted in Sarah Bradford Landau and Carl W. Condit, *Rise of the New York Skscraper 1865-1913* (Yale, 1996), p. 56.

[23] *Scientific American*, 24 January 1874.

[24] Carl W. Condit, *The Chicago School of Architecture: A History of Commercial and Public Building in the Chicago Area 1875-1925* (Chicago, 1964), p. 129.

[25] As quoted in Thomas J. Misa, *A Nation of Steel: The Making of Modern America 1865-1925* (John Hopkins University Press, 1995), p. 57.

[26] Alan Burnham, 'Forgotten Engineering: The Rise and Fall of the Phoenix Column', *Architectural Record*, April 1959, p. 224.

[27] Alan Burnham, 'Forgotten Engineering: The Rise and Fall of the Phoenix Column', *Architectural Record*, April 1959, p. 223.

[28] Phoenix columns were used in the construction of British piers in the mid-to-late-19th century. One specialist contractor, Downson, was granted two patents for analogues of the Phoenix column in 1863, one with internal flanges (No. 20 of 1863), and the other with the flanges appearing externally (No. 1937 of 1863).

[29] I am grateful to Lawrance Hurst for this information.

[30] Although it is recorded that 'All the girders were rolled and built up in Staffordshire, and brought, ready for fixing, by rail' (*The Builder*, 27 May 1881, p. 606) in all likelihood the components of the Phoenix columns were manufactured in Belgium. Rownson, Drew, and Co., whose fabricating yard was sited at Princes Wharf, Commercial Road, Lambeth, certainly used Belgian iron for their rolled joists and compound girders, and it seems unlikely that Staffordshire ironworks were rolling such specialised sections as flanged segmental arc segments, whose only (untried) market was for Phoenix columns. At this date, Belgian iron had a disreputable name among British engineers, a reputation promoted by Staffordshire ironmasters, whose interests were threatened – understandable, given the rate at which Belgian structural iron was being taken up by British architects.

[31] Jonathan Clarke, 'Early Structural Steel in London Buildings' (English Heritage Survey Report, October 2000).