ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

HISTORIC BUILDINGS REPORT

THE ROYAL ARSENAL, WOOLWICH

VOL II

The Royal Brass Foundry
The Royal Carriage Factory
The Grand Store
New Laboratory Square
The Paper Cartridge Factory
The 'Armstrong' Gun Factory

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Fortress House, 23 Savile Row, London W1X 2JQ
tel: (071) 973-3080 fax: (071) 494-3998

ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

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The Royal Arsenal, Woolwich

The Royal Brass Foundry

Summary

The Royal Brass Foundry at Woolwich Arsenal of 1716-17 is an early industrial building of outstanding importance. It was substantially rebuilt in 1771-4, but the precise nature of the rebuilding has not previously been traced in detail. The original form of the building has thus remained unclear. It is here shown that the Brass Foundry was originally entirely timber framed within a brick shell, and very much like a barn in its internal appearance. It comprised a long tall nave with clerestorey lighting flanked by continuous low aisles within which the foundry furnaces were housed towards the south end. A timber tower at the north end apparently accommodated a vertical gun-boring machine. The principal surviving feature of the original interior is the framing of the roof. The roof timbers are of great interest, particularly for evidence of the adaptation of conventional forms for their use as a gantry. The work of 1771-4 involved virtually complete rebuilding of the south or furnace end of the building as well as rebuilding of the tower in brick.

Report

Introduction

The Royal Brass Foundry was erected in 1716-17 as the first great structure for the manufacture of guns on Woolwich Warren. It survives as a powerful reminder of the scale and grandeur of operations on the Arsenal site at this early date. Its significance is, however, much wider. It is a rare surviving example of a purpose-built, large-scale machine shop from the very early stages of the industrial revolution.

The Brass Foundry is, in many respects, extraordinarily well documented. It was extensively altered and part rebuilt in 1771-4 under the direction and at the insistence of Jan and Pieter Verbruggen, appointed master founders at Woolwich in 1770. Its form and use following these changes are marvelously recorded in a remarkable series of fifty watercolour drawings of c1776-8, all recently published.[1] In addition documentary references to matters relating to construction and alteration of the building through the 18th- and 19th-centuries have been assiduously transcribed and published.[2] Yet, despite this wealth of information, the original shape and construction of the building remain unclear.

This report, based on inspection of the building fabric set against the published documentation, advances findings leading to an elucidation of the building's early form. These are in some measure speculative; some questions remain for further research and investigation.

The Brass Foundry Briefly Described

The Board of Ordnance decided to build a Brass Foundry at Woolwich following an accidental explosion in May 1716 at Bagley's foundry in Moorfields. The allocation of responsibility for the design of the building is not a central purpose of this report. However, this is a question that has given rise to much rumination over many years so it should not be ignored. The traditional attribution of the Brass Foundry with a number of other Board of Ordnance buildings of the period 1715-24 to Sir John Vanbrugh has been convincingly unpicked.[3] Most of these buildings have been reattributed to Nicholas Hawksmoor, though

not the Brass Foundry. It lacks the architectural features present in the other buildings that are characteristic of Hawksmoor. It seems probable that the design of the Brass Foundry was handled internally by the Board of Ordnance through procedures established in 1714 by Brigadier Michael Richards, Surveyor General, under the auspices of the Duke of Marlborough, Master General of Ordnance from 1702-12 and 1714-22. Responsibility for the design of the building would have rested with the divisional engineer based at the Tower of London.[4] The Brass Foundry does seem to betray the hand of an engineer; form follows function, and where architectural ornament is introduced there is a touch of eccentricity, as in the 'rustication' of the entrance pilasters. The 1716-17 brickwork was carried out by Messrs Lidgbird and the carpentry by William Ogborne.[5] The 1771-4 works were overseen by the Verbruggens and the principal contractors were John Groves, bricklayer, and Thomas Churchill, carpenter.[6]

As it stands today the Brass Foundry is a brick structure with several components. For convenience these can be articulated using ecclesiastical terminology. At the core there is a tall nave on a north-south axis. To the east and west there are aisles, each in two sections, with hipped roofs. A late-1970s refurbishment of the building largely restored the east wing to its late-18th-century form, removing late-19th-century additions with much replacement of fabric and without reinstating an entrance porch.[7] Its northern five bays are single-storeyed, with an entrance in the former porch position in the southern bay. Further south there is a two-storey three-bay block. On the west side there is a similar two-storey block to the south, but the north section of the wing was rebuilt as a broader single-storey block c1878, when the building was converted for the making of small ammunition castings for the Arsenal's Royal Laboratory.[8] An entrance porch corresponding to that to the east has also

been removed, though its south return wall survives.

The north end of the building looks down an avenue leading through the Arsenal to the river. To the centre a 2-storey-and-attic 'tower' with a cupola corresponds in width to the nave and presents an ornamental façade, with Royal Arms over a tall entrance with a robust surround. On the keystone of the entrance arch are the Arms of the Duke of Marlborough and the date 1717. The cupola, apparently not added until 1722,[9] does not house a clock or a bell and appears to be an entirely ornamental feature. This 'tower' is flanked by single-storey wings each of three bays that extend further east and west than the rest of the 18th-century building, as if transepts.

The south end of the building is awkwardly butted up against the site's boundary wall. A single-bay rectangular two-storey block of somewhat lesser width than the nave and aisles together was slightly extended in the early 19th century, perhaps in 1803,[10] with canted angles to accommodate the boundary wall. The brick to this late addition is slightly greyer than that used elsewhere which, though certainly of more than one phase, is not readily differentiated, largely because there was so much replacement in the 1970s. There are leaded flats to the south flanking a hip that terminates the nave roof, all behind a parapet - a feature otherwise absent from the building.

The internal spaces of the Brass Foundry are currently difficult to grasp because of the insertion and filling of storage racking throughout. The drawings of the 1770s therefore provide a particularly useful visual aid for any modern visitor. They show the northern five bays of the large central nave as wholly timber framed - open to the roof and to the single-

storey aisles under clerestorey lighting.[11] To the east this arrangement survives, ignoring modern infill. The surviving mid rail below the north-east clerestorey windows has been reinforced with a cast-iron girder, possibly related to the presence of line shafting along the east side of the nave as witnessed by a bearing box in the 'tower' south wall. A steam engine to serve the Brass Foundry was erected in 1848.[12] The internal timber frame and clerestorey along the west side of the nave have been replaced by a brick wall, presumably part of the c1878 rebuilding of the north-west aisle. The south end of the nave had a gallery, no longer surviving, supported by internal brick walls with stone end piers. To the east and west these walls survive functioning as supports to the nave and aisle roofs, and thus, to the east, as a continuation of the timber wall frame. They are of three bays with upper and lower arcading and separate the nave from the two-storey sections of the aisles. The central bays of these walls mark the site of the inner faces of two of the 1770s furnaces from which molten brass was poured into pits in the nave floor.[13] From 1774 there was a third furnace at the south end of the building, housed in the south block behind another internal brick wall which has since been removed. Returning to the aisles, the north return walls of the taller sections have ground-floor broad elliptical brick arches on stone corbels, latterly infilled.[14] To the north the 'tower' is separated from the nave by a brick wall with a formerly open triple arch with stone piers.[15] Elliptical brick arches in the 'tower' east and west flank walls lead to the 'transepts'.[16] These arches are now infilled, but in the 1770s the west transept was open to the vestibule under the tower and to the aisle. The east transept is and was then partitioned off.

There is no purpose in rehearsing the use of the building under the Verbruggens in detail as it is so well chronicled elsewhere. Briefly, there were entrances from the north, east and west

with a functional division of the building into south and north areas. The south end of the building was the foundry proper, given over to three furnaces and their corresponding pits. It was densely built up with these structures and the related arcaded internal walls. The furnaces were sited in the nominally 'two-storey' sections of the aisles and the south block. The casting pits were in the nave in front of the furnaces. These are said to survive in part, but inspection of the pits was not possible in the course of this survey. A gallery over the south part of the nave allowed workmen to operate above the pits, in particular working a windlass drum with tackle for lifting heavy weights. The heavy timbers of the roof also supported chains and ropes for lifting.[17] The north part of the building was more open with free circulation between spaces and largely clear workshop floors used for model and mould making. The 'tower' to the north was somewhat set apart by its internal brick arcading. At ground level it was a vestibule withs a beam scale and clerks' offices.[18] The west transept was a workshop housing clay for the model making.[19] The east transept was probably a drawing office and pattern room.[20] Gun boring took place in a nearby building.[21]

The Rebuilding Work of 1771-4 Reassessed

Comparison of the standing building with the 1770s drawings makes it clear that the basic form of the building has not been radically altered since, with the exception of the c1878 extension to the west. What is much less clear is what the building was like prior to 1771. To arrive at any conclusions it is necessary to establish the nature of the building work undertaken in 1771-4 when the Brass Foundry was said to have been 'completely altered and repaired and very considerably enlarged'.[22]

The main thrust of the building work of 1771-4 was a remodelling of the south end of the building for the addition of a third furnace and the adaptation or replacement of the two existing furnaces.[23] Early plans[24] compared with the 1770s drawings and a largely reliable reconstruction of the 1770s plan[25] indicate that this involved the blocking of an entrance position to the south with an extension for the third furnace. A short southwards projection of the nave that included an entrance served by a gate in the boundary wall was replaced by the existing rectangular south block minus its early-19th-century extension. Both additions have always had a blind south wall. They were reroofed in the mid-to-late 19th century with an iron-framed hip. However, the form of the 1770s roof and the fact that is was an addition is indicated by a collar attached to the south face of the south truss of the main roof. This is notched for clasped purlins, one of which survives. This roofing feature does not occur elsewhere in the building.

The original furnaces were in the aisles flanking the nave near its south end.[26] Their replacement in 1771-4 clearly involved substantial works, but the precise nature of these is complex to determine.

In July 1771 the Verbruggens suggested making arches near the furnaces to reduce fire risk and in 1772 payment was made to John Groves, bricklayer, for 'carrying up the piers and arches under the cupola and between the furnaces'.[27] The work 'between the furnaces' appears to refer to the east and west internal walls which support the timber wall plates along the nave. That these walls are secondary can be confirmed. There are timber pegs in the wall plates immediately below all the nave roof trusses. These are present not only to the northeast where timber posts survive, but remain visible along the full length of both plates

on their east faces. It seems clear that the east and west internal brick walls and associated stone piers replaced timber framing in 1771-4.

A degree of uncertainty is introduced to this interpretation by Barker's 1749 map,[28] which shows only five pairs of internal posts, none at the south end of the building. These extend into the tower area and do not correspond with surviving bay divisions. No documentation for any substantial work between 1717 and 1771 has been cited in the published works. Against the possibility that the lower parts of the east and west internal brick walls are original and that upper-level timber posts rested on low brick walls there are no discernible breaks between upper and lower sections of the walls, though the faces of the walls have been painted, obscuring the details of the brickwork. Yet, a small part of the east internal wall does appear to antedate the rest. Given, in addition, the irregularity of the bay rhythm the internal walls can be confidently ascribed to the 1770s. It is reasonable to conclude that the 1749 map is misleading in this detailed respect.

The upper arches in these walls are apparently later insertions as they are not present in the 1770s drawings.[29] There was then apparently more solid upper walling with small segmental-headed openings flanking the furnaces. At both levels the broad arches of these internal walls (as well formerly as those of the removed south internal wall) are tied by iron rods through the stone end piers. These are secured by a variety of bolts and plates. At the lower level long vertical bolts were used where space allowed, elsewhere there are screw bolts over long plates. These ties are present in the 1770s drawings.[30] At the upper level the iron ties are, with the arches, later.[31] They have circular plates to the south and substantial moulded cast-iron plates to the north, the latter forming in effect reveals to the clerestoreys. These ties

suggest that the upper openings in the internal walls may have been inserted in the early 19th century, perhaps in 1803 when extensive repairs and alterations are recorded, or 1807 when two windows were requested to improve light to the foundry.[32] The infilling of the arches was part of the 1970s refurbishment.[33]

The insertion of the internal walls in the 1770s provided solid and fire-resistant screens in front of the furnaces, as well as firmer support for the gallery and 'working' trusses of the roof. Their form was dictated by the need to allow free circulation and admit natural light to the nave in replacing a timber frame. This open-ness made the stone piers and iron ties necessary.

The nave gallery as present in the 1770s relied on the brick walls for support. The level of the gallery can still be discerned from a small stone projecting from the east wall at its north end as well as from a setback in the walling above the east furnace front wall.

The east and west furnaces of the 1770s rose through the full height of the taller south sections of the aisles.[34] There were no floors in the aisles, so they were not properly speaking two-storeyed. In the east aisle roof the tie beam over the position of the great furnace has been cut and replaced with wrought-iron ties at a higher level (Section A-A). This may indicate the headroom required for the furnace.

The furnaces of the 1770s were larger than those existing previously. It is evident that the taller sections of the aisles were raised in height in 1771-4 to accommodate the new furnaces. Several peculiarities in the fabric point to this conclusion. The lower part of a principal rafter

for a straight truss has been incorporated in the hip at the south end of the single-storey section of the east aisle. In addition, there is a slight setback in the external brickwork of the taller section of the west aisle below the upper sill level, and the plat band of the east side is absent. Further, there is boarding with painted brickwork fixed to the outer or east face of the east wall plate to the nave roof near its south end. This is nonsensical unless it was once external. Finally, it is difficult to conceive the upper-level lateral walls on the north sides of the taller sections of the aisles co-existing with timber framing along the nave. The elliptical brick arches under these walls and across the aisles have iron ties, fixed to the inner walls with 'S' plates. These are slightly to the south of the north piers of the internal walls. This irregularity can be understood as the result of the complex nature of the 1770s alterations rather than as separate building phases.

The prominent east aisle elevation has none of the revealing untidiness of the obscured west elevation. However, architecturally it does bear out the proposition that the south ends of the aisles have been raised. The conjunction of two plat bands at ground-floor impost level and between the storeys is awkward. Further, the now demolished but formerly architecturally significant porches were awkwardly positioned at the junction between one- and two-storey blocks.[35]

An additional point about the east elevation of the taller section of the aisle is that the central window on the lower level was blind until latterly as this was the furnace position. That it was designed to be blind can be confirmed by the early plan[36] and comparison with the west side where the wall (now behind a boiler house) has three blind openings externally while internally there are only traces of the outer two openings.

It thus appears that the reworking of the south end of the Brass Foundry in 1771-4 comprised virtually complete rebuilding below wall-plate level of everything south of the east and west entrance porches. The lower parts of the aisle walls were retained, though to the east the brickwork is not readily divided into separate phases, and the aisle roofs were simply raised.

The payment to John Groves in 1772 for 'carrying up the piers and arches under the cupola and between the furnaces'[37] needs to be revisited with reference to the north end of the building. In July 1771 the Verbruggens had represented that the 'wooden tower' was rotten, urging repair in brick, then submitting plans that included arches.[38] Within the 'tower' on the first floor braced timber framing survives just inside its south wall. There are also breaks in the inner faces of the 'tower' east and west walls where the transept north walls return. These features appear to indicate that the walling of the south, east and west sides of the 'tower' south of the transept north walls is datable to 1771-4. The triple arcade in the 'tower' south wall has chamfered stone piers like those in the internal walls flanking the nave. The elliptical arches to the 'transepts' are like those across the aisles. Incidentally, Paul Sandby's view of the Brass Foundry in 1779 shows the west return of the tower at first-floor level as without windows.

The blocking of the principal entrance to the south in the 1771-4 work made the north end the main entrance and the ground floor of the 'tower' a vestibule. The 'tower' south wall has a first-floor blocked arch-headed opening over which there is a hook towards the nave suggesting a hoist for storage over the vestibule. The upper floors of the 'tower' apparently had no more than ladder access. In the 19th century an iron spiral stair was inserted in the northeast corner of the space.

The Fabric and Layout of the Early Foundry

This analysis of the works carried out in 1771-4 leads to the conclusion that the earlier building comprised a continuous timber-framed nave of 10 or 11 bays with clerestorey lighting, flanked by continuous low aisles and surmounted by a timber 'tower', all surrounded by a brick outer shell articulated by projecting and embellished entrance features on each of its four sides. The absence of internal walls on the earliest extant plan,[39] which, without corroborative evidence, might be meaningless, turns out to be significant. There were none. As Hogg stated on the basis of the proportionate amounts paid to the craftsmen 'the original foundry building was constructed mainly of wood'.[40]

Functionally three south entrances to the nave and aisles led directly to the foundry proper with two furnaces flanking the nave. Model and mould making must have been, as subsequently, carried out on the workshop floors to the north. The final process, the boring of the guns, took place at the north end, under the cupola.[41] This suggests that the grandeur of the 'tower' north elevation might reflect its status as the point from which the finished guns emerged.

The plan is very basilican, but ecclesiastical analogy, though useful for descriptive purposes, is misleading. A more apt parallel is with an aisled barn. The Brass Foundry was built on the site of a barn and arose from the transposition of what had previously been an essentially rural craft (Wealden gunmaking in the 16th and 17th centuries) to a relatively new State-sponsored site. In the pre-industrial period barns were the most obvious of the very few

available domestic models for large-scale 'industrial' buildings, setting aside the possibility of precedents overseas. The original Brass Foundry may thus be regarded as having been conceived as a barn in fancy dress. The painted brickwork on the east wall plate is evidence that the wooden nature of the building was disguised. It is not surprising that such a building proved inadequate for the heavier and more sophisticated processes of the late 18th century.

Below roof level only fragments of the original internal fabric survive. The four timber posts to the northeast have some chamfered arrises and are 36cm square. The presence of pegs in the nave wall plates shows that there were similar posts along the length of the nave. Under the third nave truss from the south end there are paired pegs (12cm apart) in the wall plates, reinforcement where the roof was used for heavy lifting over the casting pits.

A small part of the east internal wall may survive from the early building. Brickwork around a segmental arch that was formerly in front of the east furnace[42] projects slightly from the adjoining walling, with brick courses that do not line through. At the head of this brickwork there is a slight but definite setback in line with the base of the mid rail in the timber frame that survives further north. Perhaps the posts under the 'furnace' truss stood on the heads of the original furnaces.

The original clerestorey fenestration is indicated by the survival of pegged timber stubs in the timber window sills. There is no reason to suppose that the windows were other than as illustrated in the 1770s drawings,[43] that is simple four-light mullion-and-transom windows at the centre of each bay. The south bay of the surviving clerestorey had larger eight-light windows. As this appears to have been an original arrangement it may indicate that there was

always a gallery across the south end of the nave, requiring broader windows here better to light the casting pits.

In the 'tower' massive timber braces (now boxed in) support first-floor framing of down-braced posts just inside the line of the 'transept' north walls (the upper frame mirrored on the inner side of the 'tower' south wall). Iron straps on these timbers have forelock bolts comparable to those in the roof which are certainly of 1716-17. This framing and a section of raised floor over a former hatch in the first floor to the north probably relate to the original gun-boring machine, apparently sited immediately inside the north entrance and dismantled in 1771-2.[44] It has been suggested that this would have been 'a vertical mill in which the cannon were hoisted, muzzle down, on a vertical gallows frame and lowered against a revolving cutterhead driven by a horse gin.'[45] This provides an explanation for the existence of the 'tower' and the great height of its lower storey, if not for its cupola. If there was a horse gin it must have been sited to the south of the boring machine extending into the nave.

Without internal brick walls the 'transepts' would not have been very distinct spaces. The west 'transept' appears always to have had external access from the west. The east 'transept' had an entrance in its south return, converted to a window by c1880, and since blocked.[46] The reason for this asymmetry is not evident. Perhaps the arrangement in the 1770s perpetuated that already existing, with a workshop to the west and a drawing office and pattern room to the east.

The nave roof remains largely as originally built. The redundant pegs in the wall plates are

good evidence of this because the plates are integral with the trusses which they support. These trusses are linked by double butt purlins. The survival of a clasped purlin from the 1770s south extension provides comparative dating evidence if such is needed. The roof trusses remain as illustrated in the 1770s[47] and their character in form and in detail is consistent with an early-18th-century date. The roof of the Brass Foundry is perhaps its most important surviving original feature and a fascinating example of inventive carpentry to meet special demands. Principal amongst these demands was strength as the roof was not just a covering but also a gantry for heavy lifting. It therefore has a very steep pitch; it was originally sure to have been tiled not slated.

The first truss from the original south end of the nave is just 5cm north of the stone piers at the ends of the 'furnace' internal walls (Plan). This suggests that it was just inside the original main south wall. It is a conventional king-post truss with diagonal struts to the principals from splayed joggles near the base of the post. The joggled head of the post is splayed across the full width of the principals, as is usual. There is a secondary iron stirrup strap at the base of the post; this is clearly inserted as it passes in front of a mortice for a longitudinal tie on the north side; its forelock bolts are unlike evidently primary bolts elsewhere.

Moving northwards the second truss is just south of the former furnace positions. It differs in many respects from the truss just described. It is much more heavily constructed and was clearly designed to take greater stress, in association with use for lifting. There are secondary posts and a great deal more ironwork (straps at the bases and the heads of all three posts, as well as at the bases of the principals). Notably, there are variations in the king post, with the

joggle at the head commencing halfway through the principals' width - an unusual and difficult, but stronger, construction. Less exotically, at the base of the post the struts are not set into a splayed joggle but into a square-cut broadening of the post, a reflection of the steep rise of the principals.

This stronger type of truss is repeated with further reinforcement for the truss over the former furnace and casting-pit positions (Section A-A). The diagonal struts are doubled and there is yet more ironwork with straps from the struts to the secondary posts and double straps at the principal braces. There is also a bolted bracket with a hook on the tie beam near its east end above the pit of what was the great furnace from 1774.

The fourth truss, that to the north of the furnace position, is comparable to the second. The remaining five trusses to the north are simpler (one of these was concealed by modern partitioning at the time of inspection). They lack the reinforcement of the three furnace-related trusses. There are no secondary posts and there are iron straps only at the bases of the king posts and principals. They retain, however, the unusually joggled heads to the king posts and, again unusually, there is no broadening at the bases of the posts.

The reconstructed plan of the roof at tie-beam level is striking and unusual (Plan of central roof). Bay lengths vary with three short bays around the furnace position. Denser roofing provided greater strength and more options for lifting. Horizontal cross braces triangulated and thus strengthened the frame, but also provided additional and widespread lifting opportunities.[48] They were arranged in a regular large-small diamond pattern; the original bracing, largely removed, can be reconstructed from surviving housings in the soffits of tie

beams and longitudinal ties in the same plane. The evidence of surviving mortices as well as of the 1770s drawings show that the longitudinal ties were staggered from bay to bay. Additional longitudinal timbers are nailed to the sides of the king posts at mid-height; the manner of fixing indicates that these are secondary.

The aisle roofs are simple butt-purlin collar trusses. There has been some replacement in iron to the southwest. The inner ends of the east aisle tie beams to the north rest on the mid-rail of the nave east wall frame. Similarly the raised aisle tie beams to the south rest on the wall plates.

Notes

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5 - Hogg, i, p. 257.
6 - Ibid, pp. 434-5.
7 - Public Record Office, WORK 43/1611, 'Old Brass Foundry', n.d. (c1880), plan and east elevation: RCHME, PSA Photograph Collection, G13544/32 (1969); B1317/9-16 (1975).
8 - Hogg, ii, p. 900: PRO, WORK 43/506, map of the Royal Arsenal, Woolwich, 1888: MS map of Royal Arsenal, Woolwich, 1878.
9 - Jackson/De Beer, p. 36.
10 - Hogg, i, p. 505.
11 - Jackson/De Beer, drawings 10-24.
12 - Hogg, i, p. 704.
13 - Jackson/De Beer, drawings 29-44.
14 - Ibid, drawings 10 and 13.
15 - Ibid, drawings 15, 16 and 23.
16 - Ibid, drawing 26.
17 - Ibid, drawings 29-33 and 41.
18 - Ibid, drawing 1.
19 - Ibid, drawing 3.
20 - Ibid, pp. 39, 165.
21 - Ibid, p. 43.
22 - Ibid, p. 47.
23 - Ibid, p. 40.
24 - British Library Maps, King's Topographical Collection, xvii, 25d, 'Plan of the Foundary buildt at Woolwich anno 1715': John Barker, 'An Exact Survey of the Warren at Woolwich... 1749' (Hogg, i, facing p. 274).
25 - Jackson/De Beer, p. 76.
26 - Ibid, passim.
27 - Hogg, i, pp. 431 and 435.
28 - J. Barker, op. cit.
29 - Jackson/De Beer, drawing 42.
30 - Ibid, drawings 27 and 42.
31 - Ibid, drawing 13.
32 - Hogg, i, pp. 505 and 555.
33 - RCHME and National Maritime Museum Photographs.
34 - Jackson/De Beer, drawings 42 and 44.
35 - PRO, WORK 43/1611.
36 - BL Maps, King's Top. Clln, op. cit.
37 - Hogg, i, p. 435.
38 - Hogg, i, p. 431: Jackson/De Beer, pp. 41 and 165.

39 - BL Maps, King's Top. Clln, op. cit.
40 - Hogg, i, p. 257.
41 - J. Barker, op. cit: Jackson/De Beer, pp. 36, 72, 164.
42 - Jackson/De Beer, drawing 33.
43 - Ibid, drawings 11-12.
44 - RCHME photograph: Hogg, i, p. 431.
45 - Jackson/De Beer, pp. 36, 72, 164.
46 - BL Maps, King's Top. Clln, op. cit: PRO, WORK 43/1611.
47 - Jackson/De Beer, drawings 11 and 19.
48 - Ibid, drawing 11.

Recorded by Andy Donald, Peter Guillery and Derek Kendall
May 1994

Report by Peter Guillery
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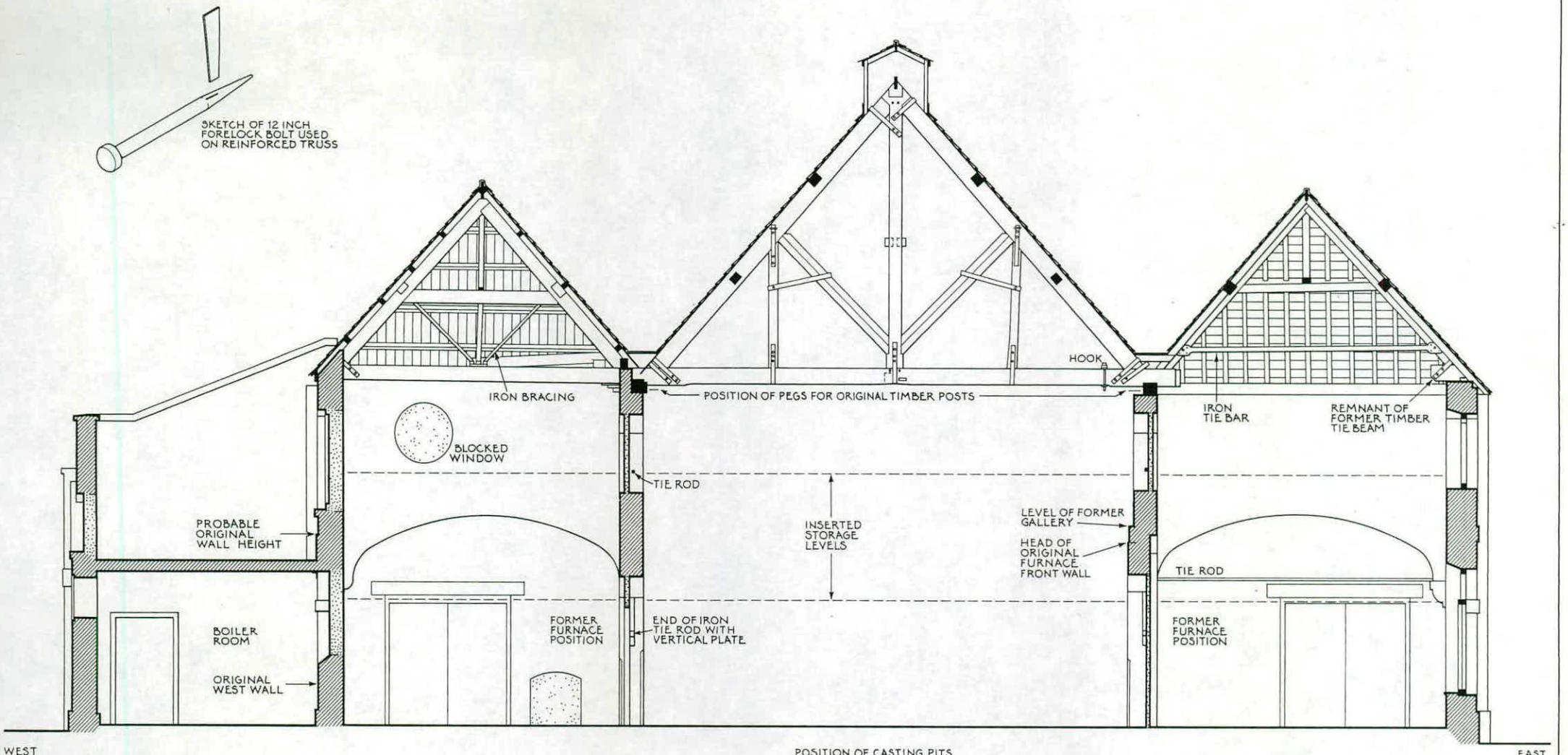
LIST OF ILLUSTRATIONS



SECTION A-A THROUGH FURNACE AND CASTING PIT POSITIONS SHOWING REINFORCED ROOF TRUSS LOOKING NORTH

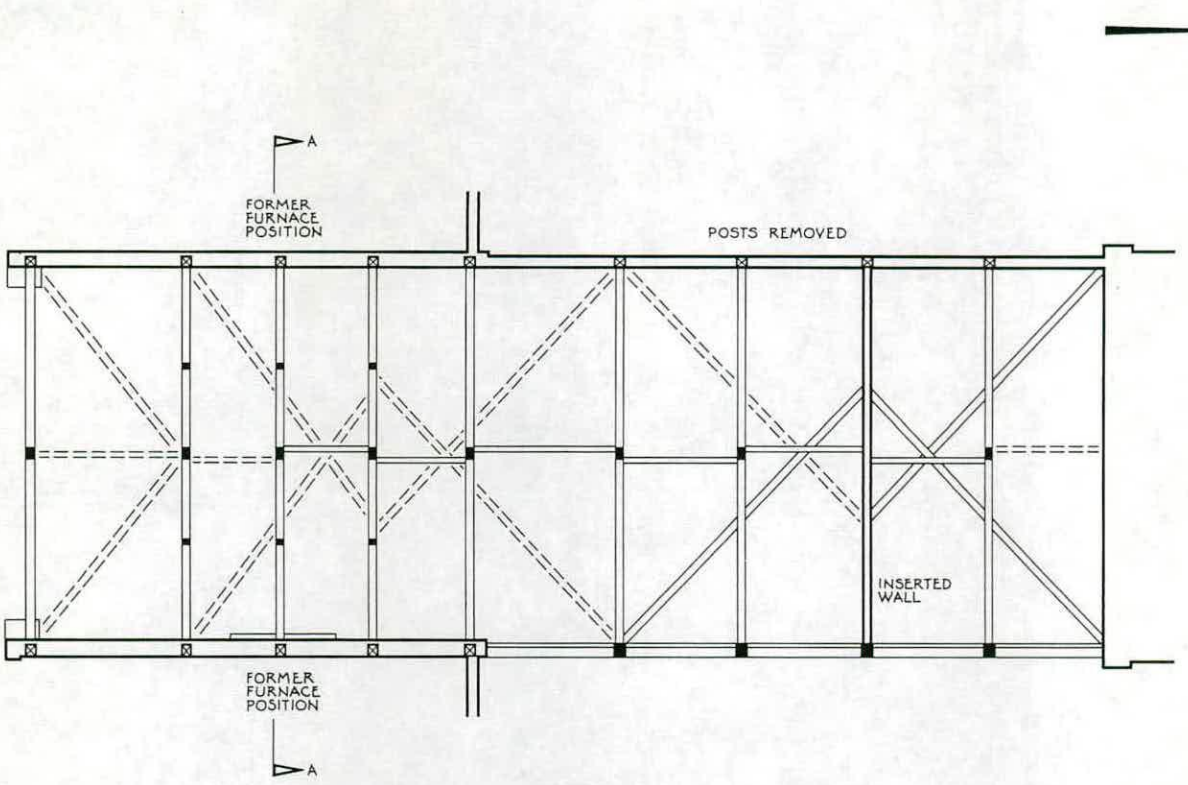
ROYAL BRASS FOUNDRY

Royal Arsenal Woolwich London SE18

Borough of Greenwich
Surveyed June 1994
Drawn scale 1:50
Grid reference TQ 440 793
NBR No. 92394

1 0 5 10 metres
5 0 10 20 30 feet

RCHM ENGLAND



PLAN OF CENTRAL ROOF AT TIE BEAM LEVEL WITH CROSS BRACING RECONSTRUCTED AND POST POSITIONS BELOW INDICATED

ROYAL BRASS FOUNDRY
Royal Arsenal Woolwich London SE18

Borough of Greenwich
Surveyed June 1994
Drawn scale 1:100
Grid reference TQ 440 793
NBR No. 92394

5 0 10 20 metres
10 0 20 40 60 feet

RCHM ENGLAND

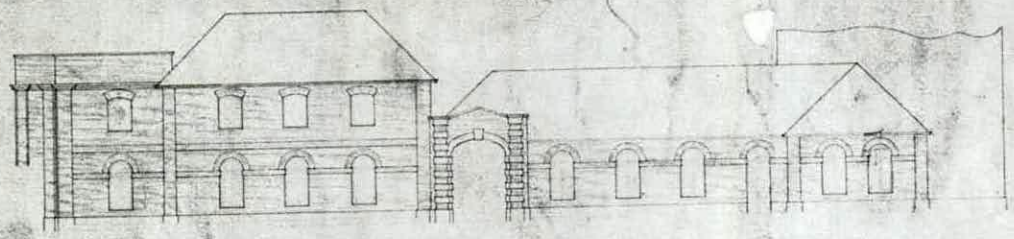

M.D.PROBERT
800 FXL

L 1008

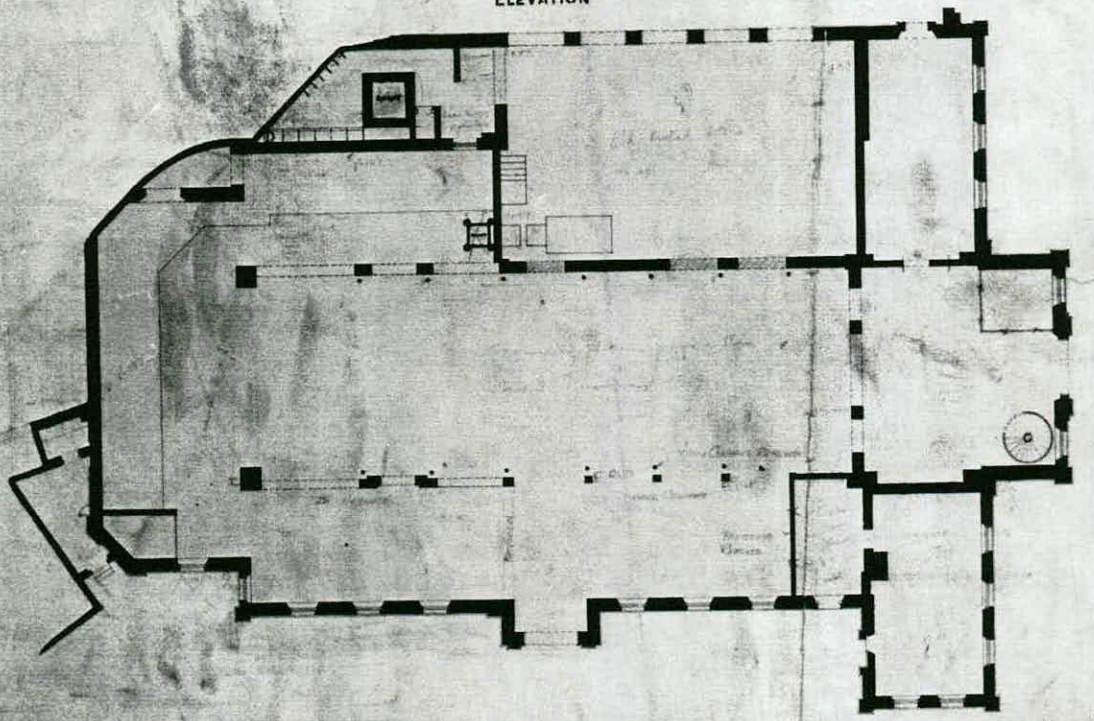
ROYAL ARSENAL WOOLWICH.

DEPARTMENT

OLD BRASS FOUNDRY

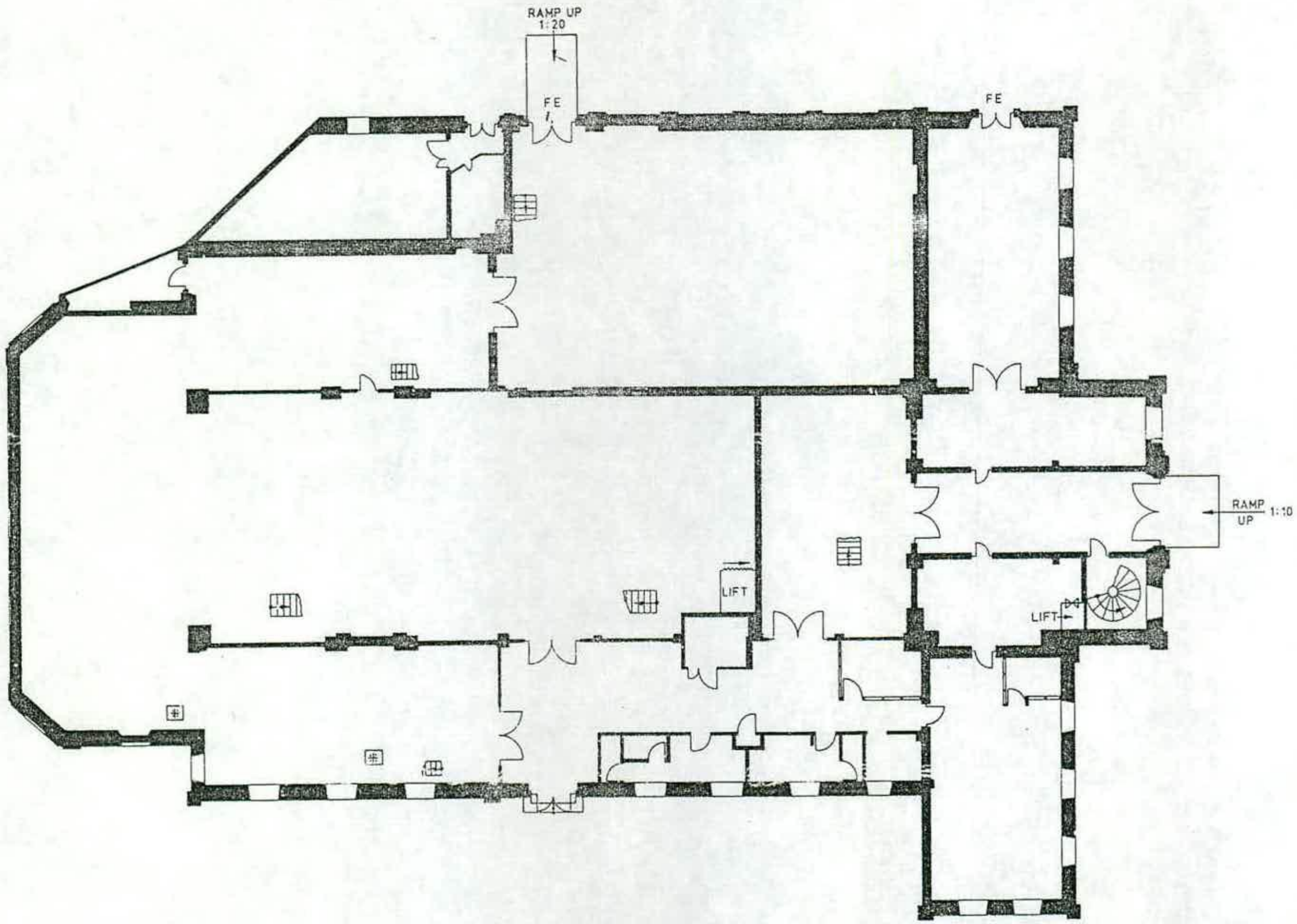


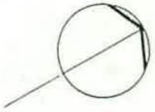
ELEVATION



GROUND PLAN

SCALE FEET TO AN INCH





GROUND FLOOR

ROYAL ARSENAL WEST
ROYAL BRASS FOUNDRY

DRAWING NUMBER - A1-980-61889 - THIS SHEET
DRAWING NUMBER - A1-980-61893 - FIRST FLOOR
DRAWING NUMBER - A1-980-61894 - SECOND AND THIRD FLOOR

FE - FIRE EXIT
⋕ UNDERFLOOR ACCESS (DISUSED)

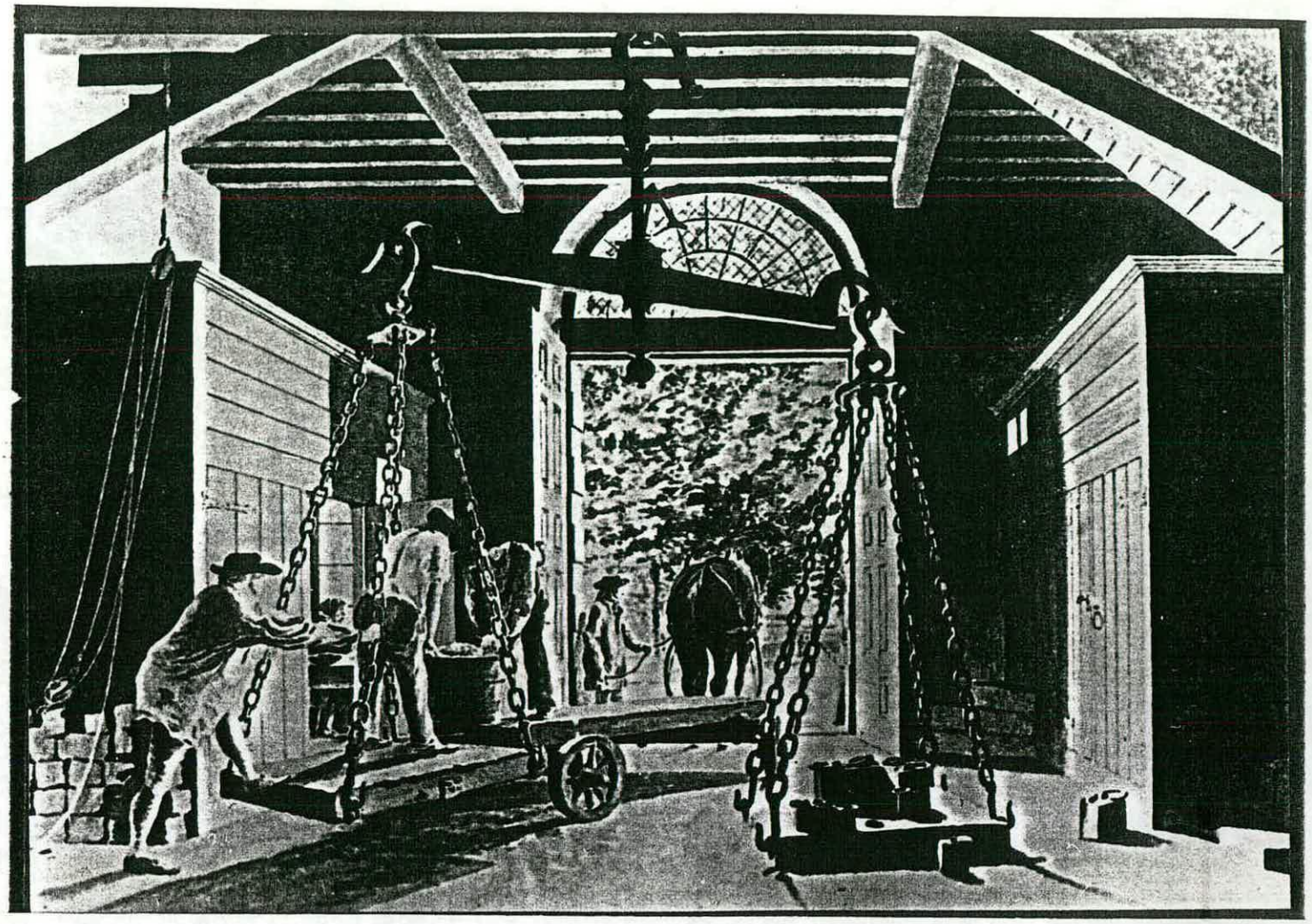
D.O. APP. [illegible]
DRAWN J. BAKER
ORIG. SCALE $\frac{1}{8}$ IN. = 1 FT.

FEET
0 2 4 6 8 10 20 30

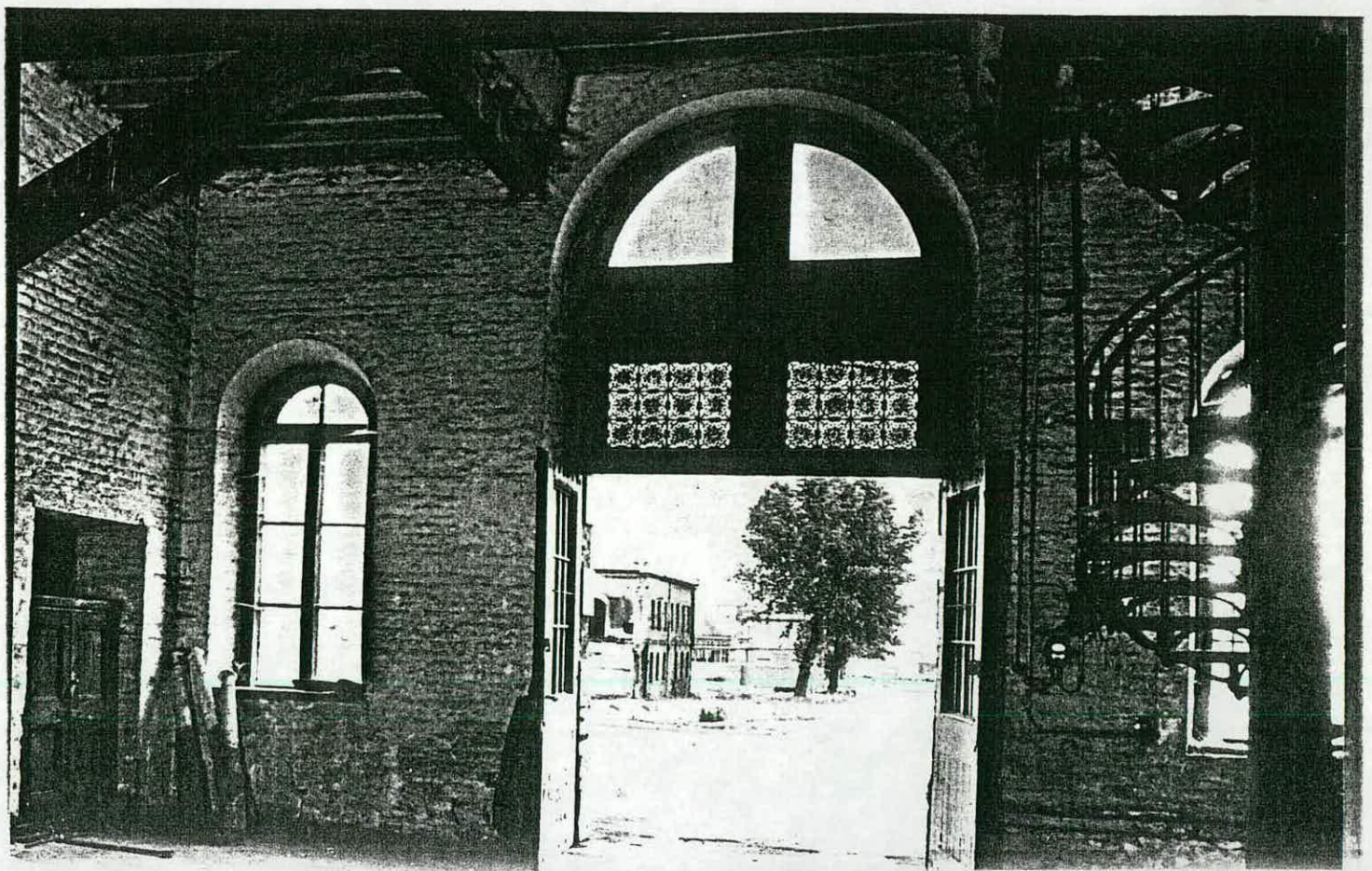
NOTE:-
THIS DRAWING REPRESENTS THE GENERAL LAYOUT OF THE BUILDINGS / ROOMS / FLOOR SPACE WHEN ACCURATE ANALYSIS OF AVAILABLE SPACE IS REQUIRED MEASUREMENTS SHOULD BE CHECKED

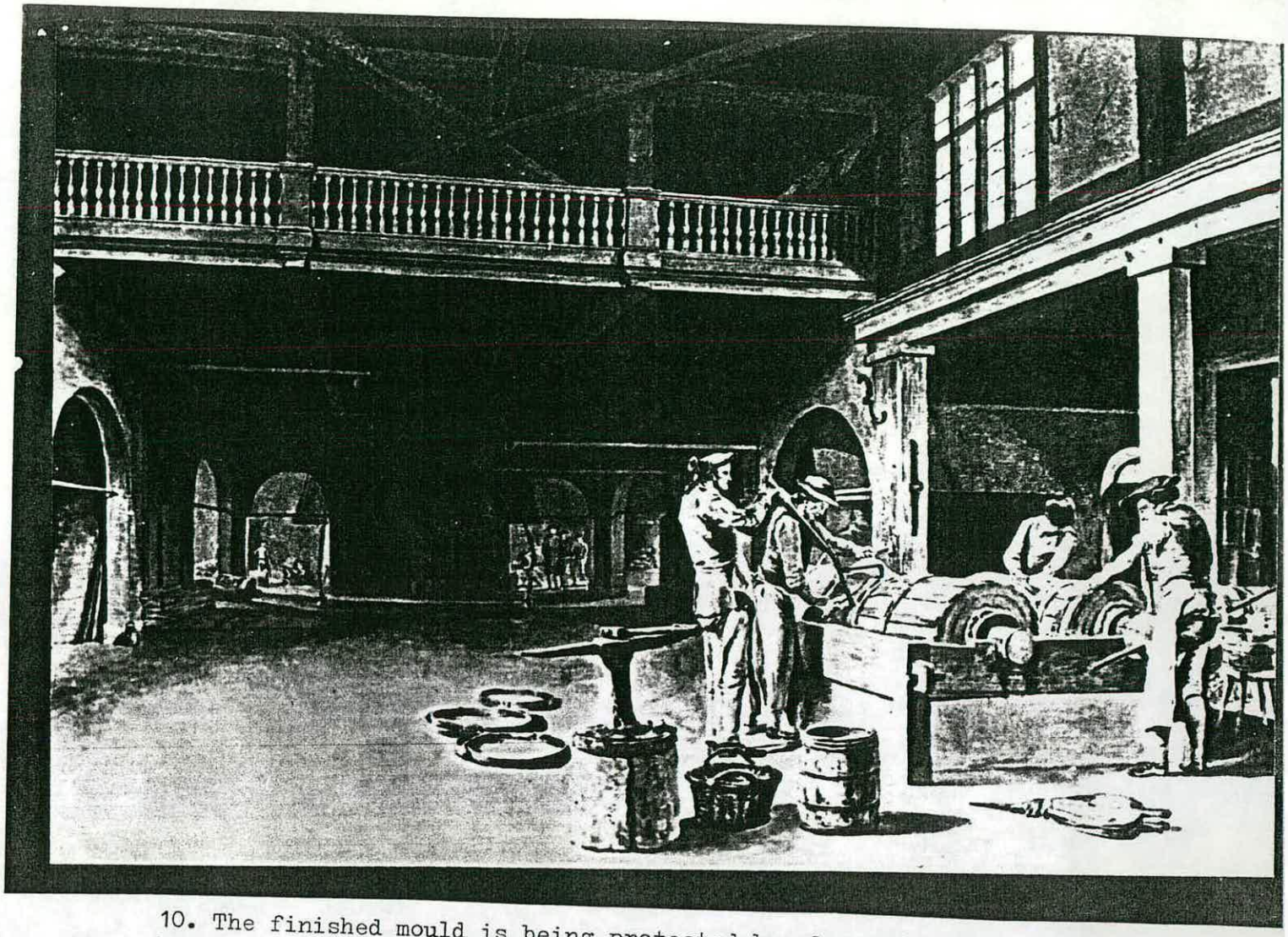
CHANGE	MOD NO.	ISS.	DATE
ACCESS STAIRS TO STORAGE LEVEL 1 ADDED		2	24-1-89
CERTIFIED		1	24-8-88

DRAWING NUMBER A1-980-61889

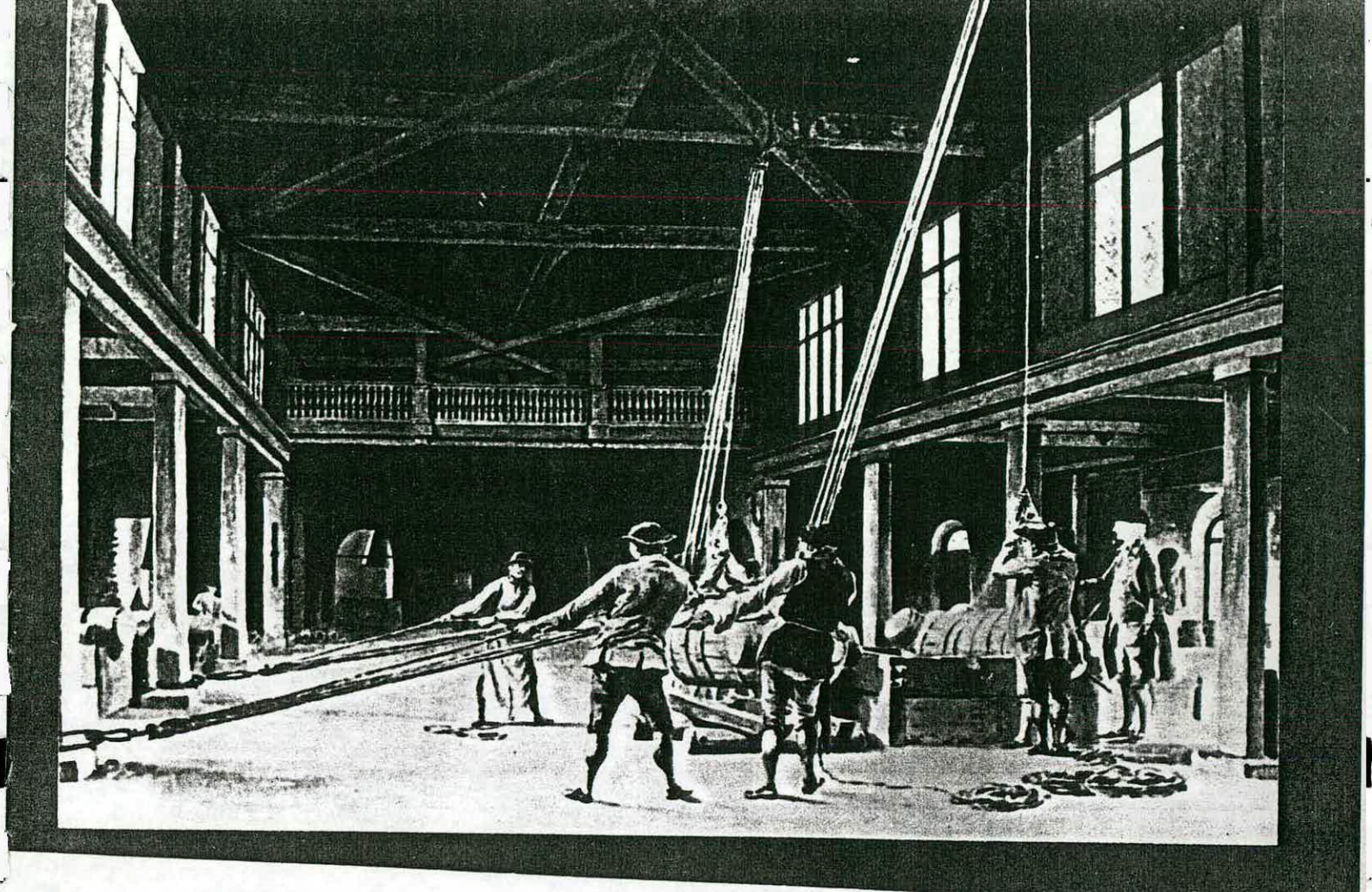


1. View from the vestibule of the Royal Foundry looking north-east towards the Thames. Note the large beam scale which was an essential piece of equipment, not only to measure the ingredients of the melt, but also to weigh the finished ordnance and to determine its Centre of Gravity.



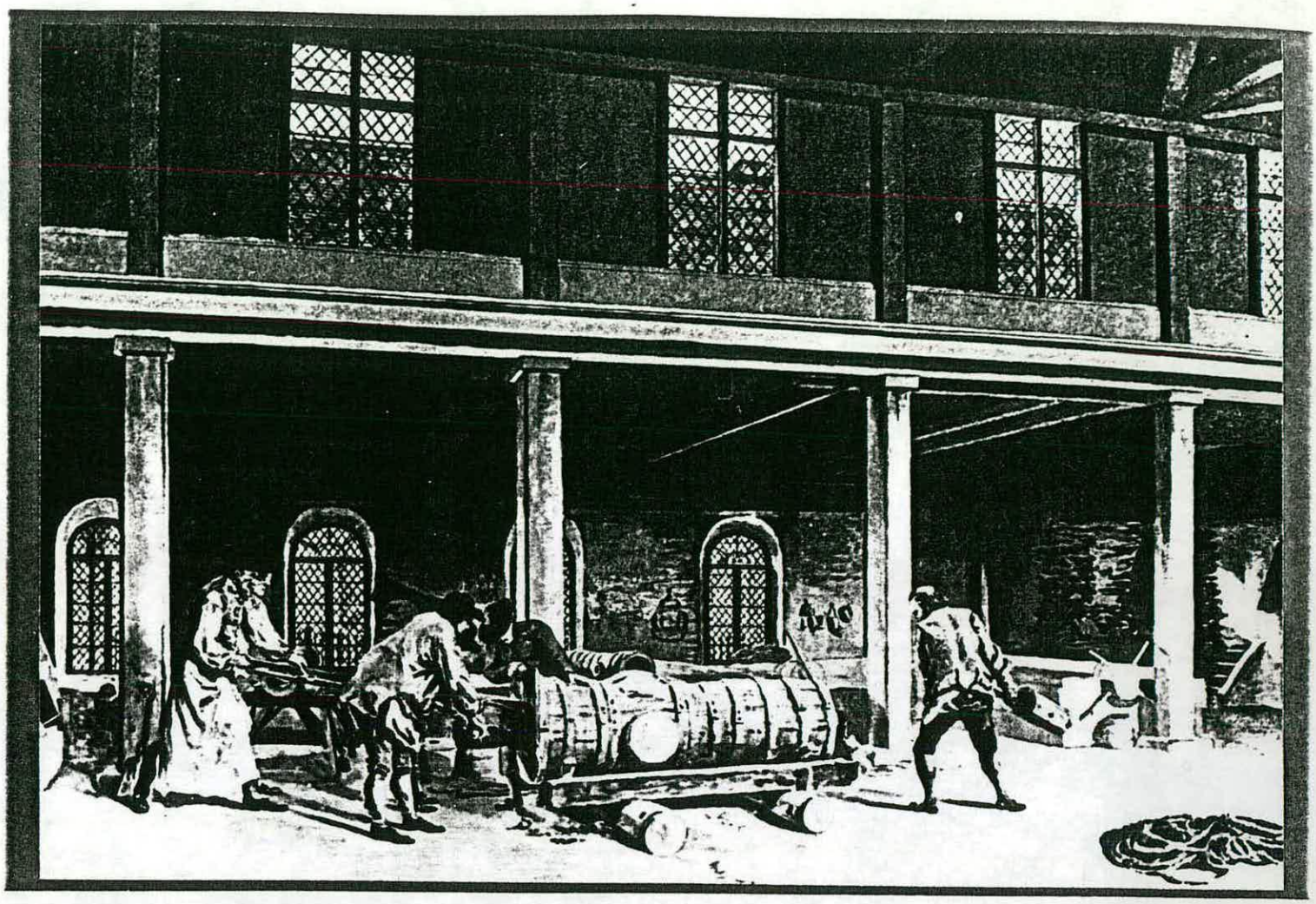


10. The finished mould is being protected by slats of wood bound with iron hoops.

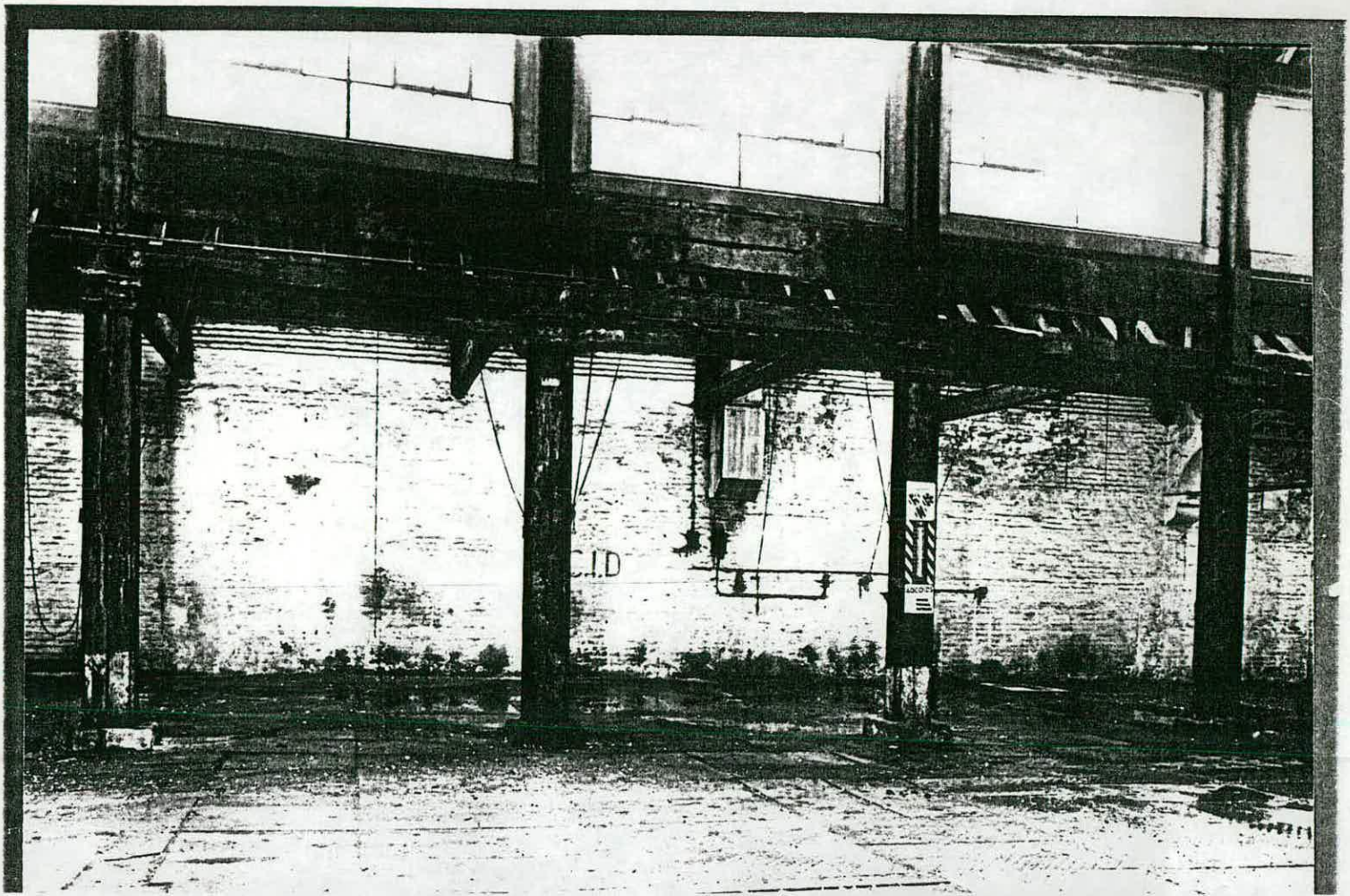


Top :- Negative No. B 7406.1

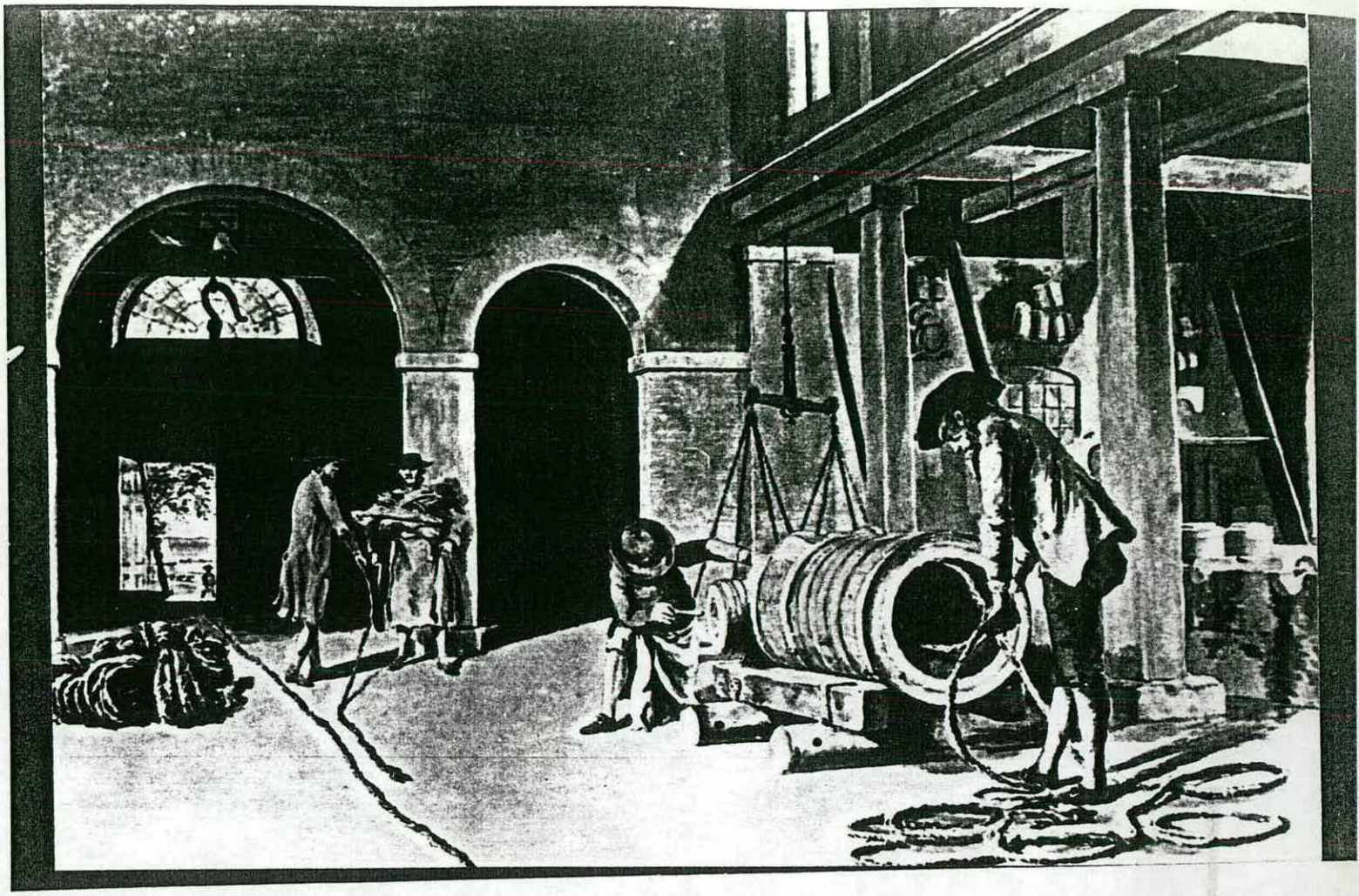
11. A completed mould is being lifted off its turning frame for removal of the pattern.



12. The clay model is ready to be disengaged from the mould. The worker has clouted the greased tapered wooden spindle, freeing it. The workers on the left are carefully withdrawing it.

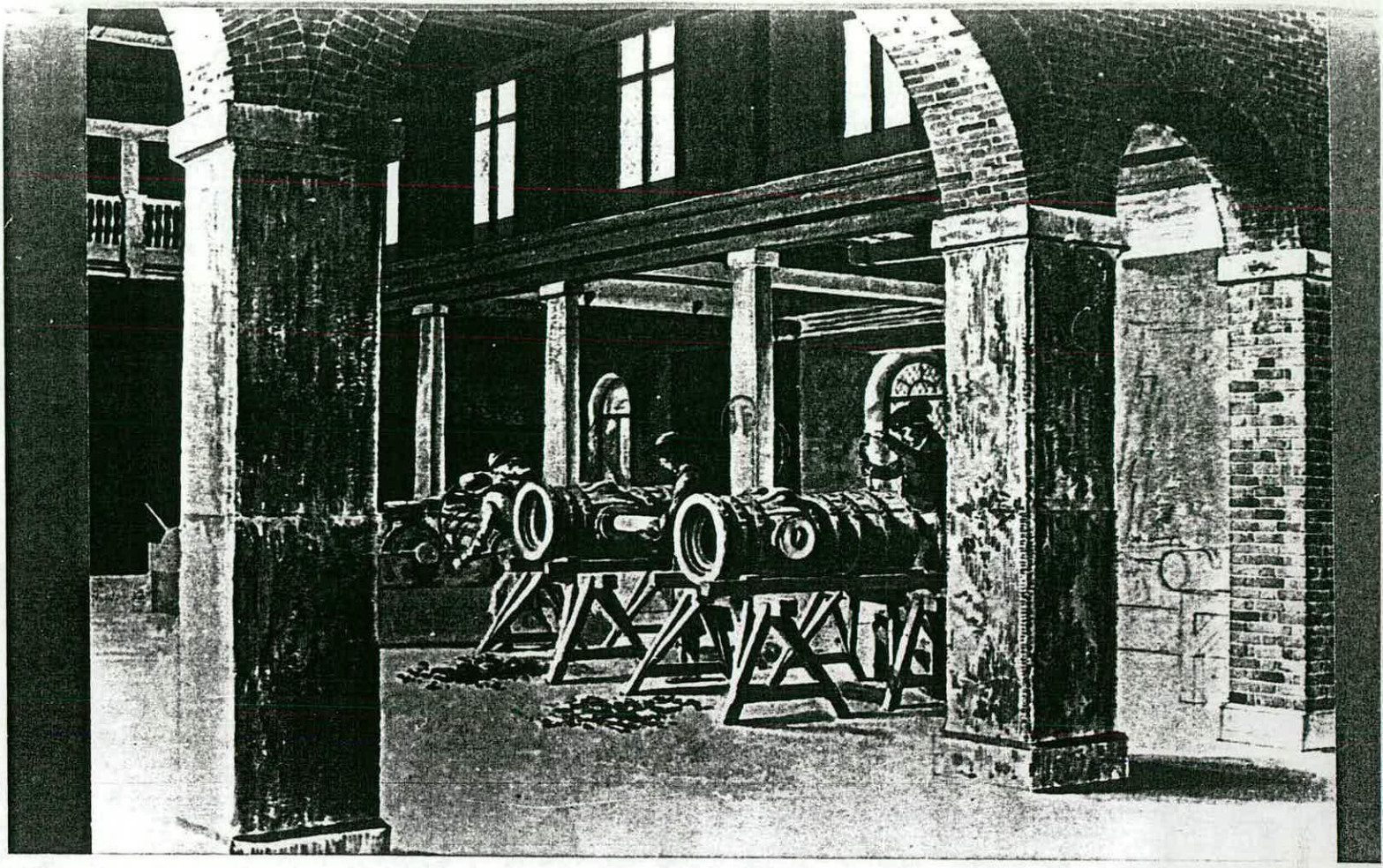


13. The removal of the spindle continues.

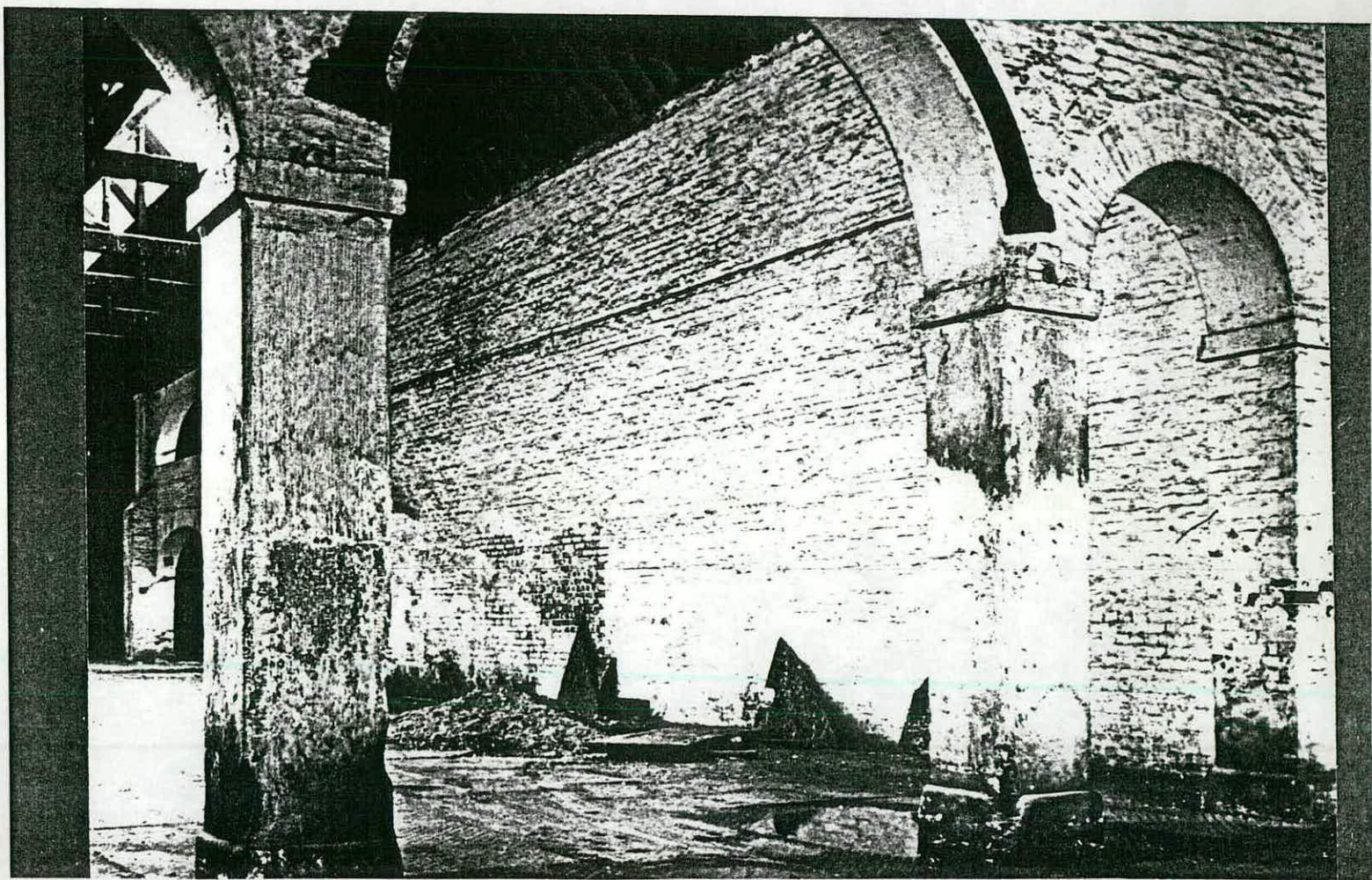


14. The coiled rope is being removed. Note the fellow in the background being used as a swift to coil the rope, which, of course, is re-usable.

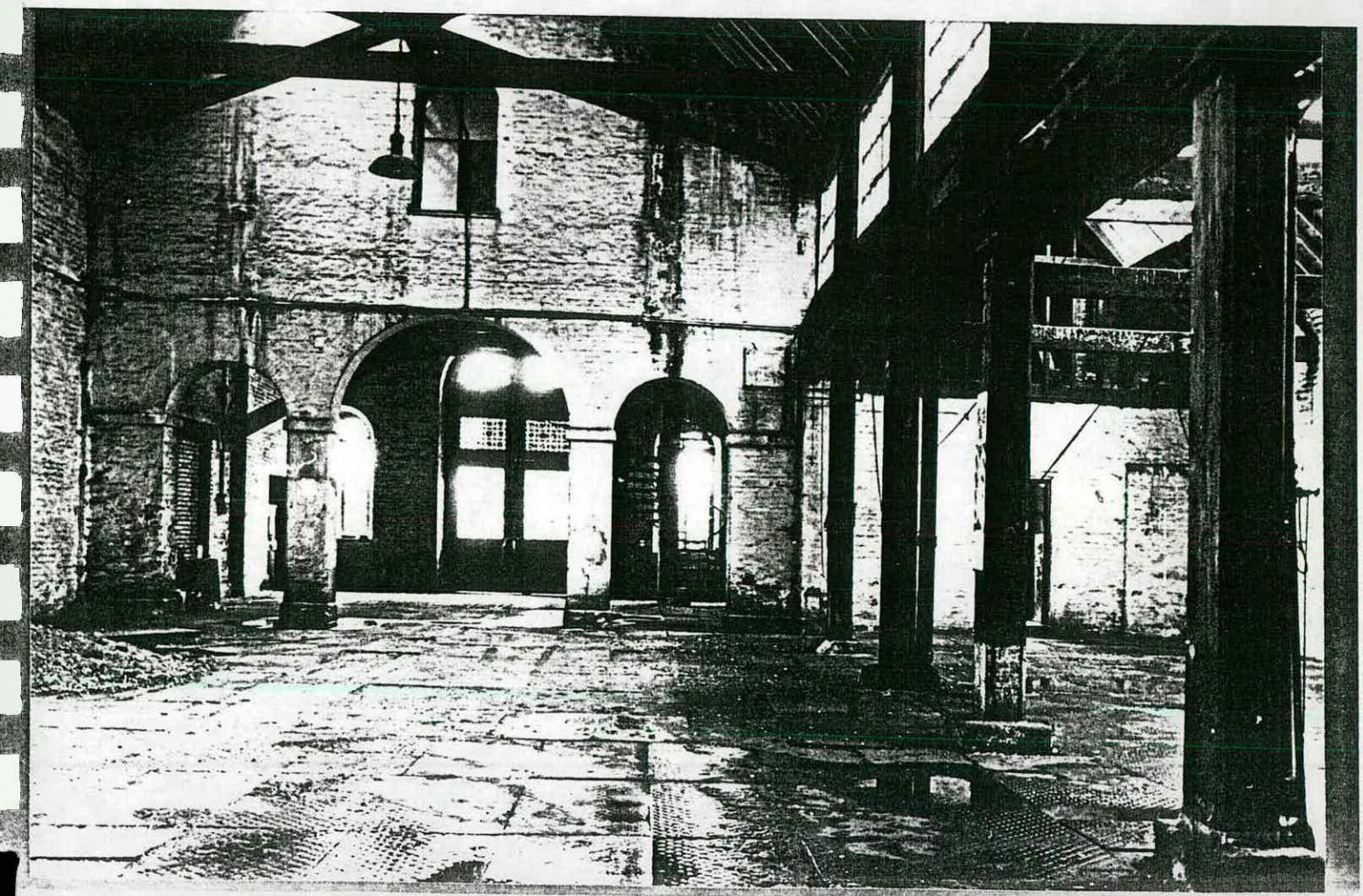
15. The final stage of clearing the pattern from the mould - the clay is being removed.

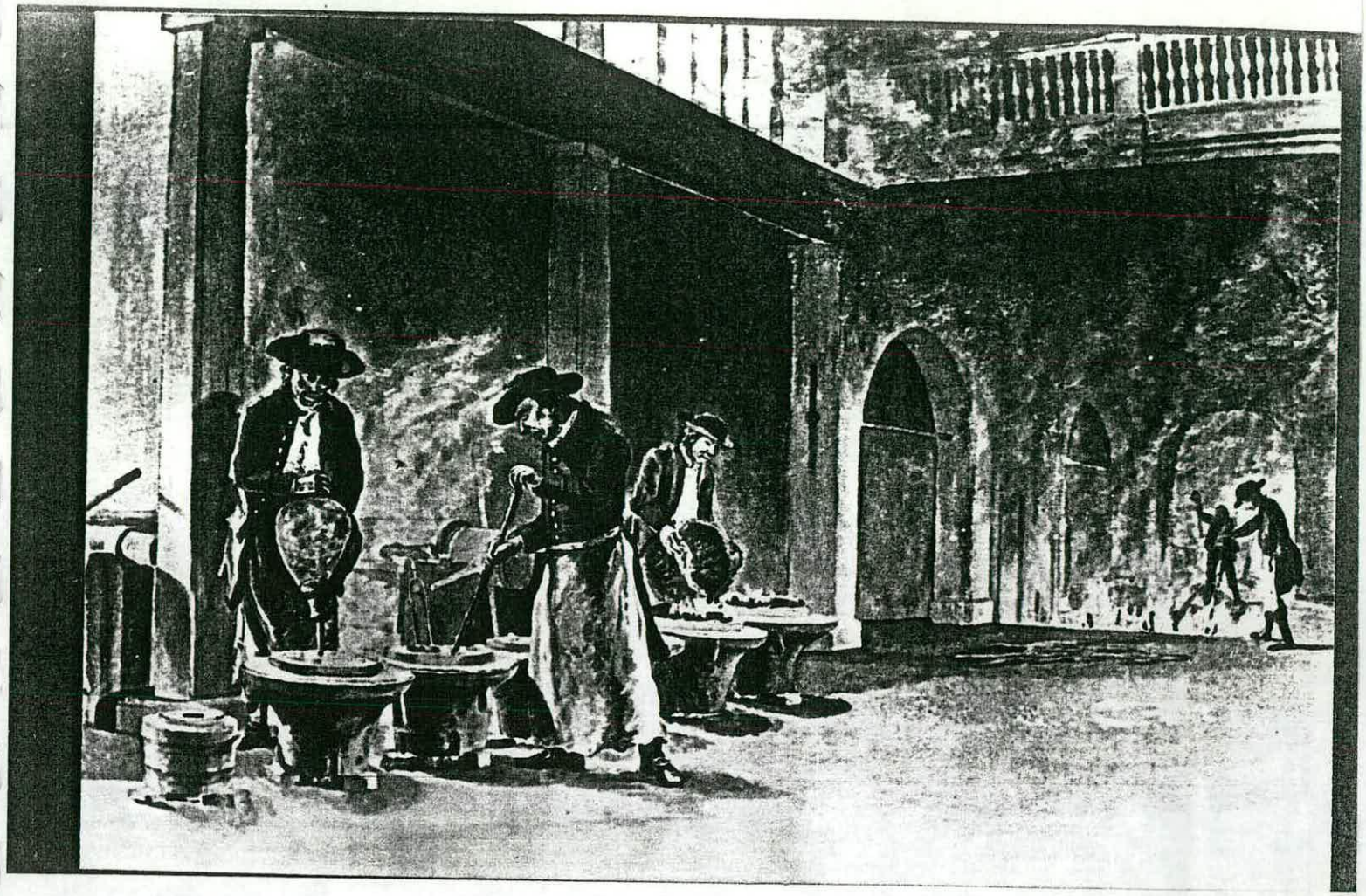


16. Two small howitzers are shown that have been cleared of their patterns. The worker in the middle is smoothing and gauging the trunnion holes whilst the man on the right is drilling a Sprue hole, eg a vent for the air to escape when molten metal is poured in and so reduce the risk of blow holes.

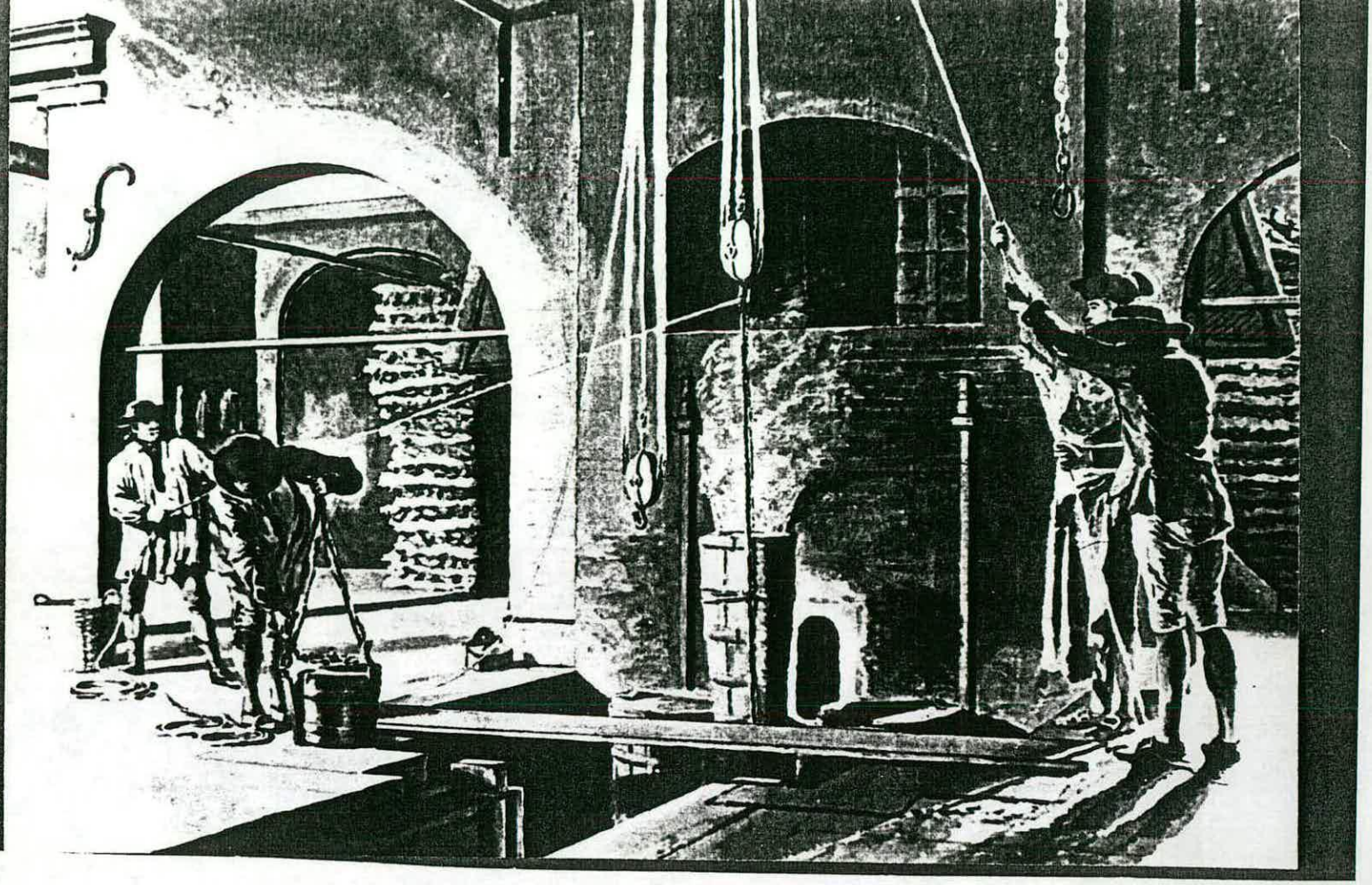


23. The mould being cleared of its brick armature and clay model. Bore and trunnion holes are being examined for flaws by the light of a candle.

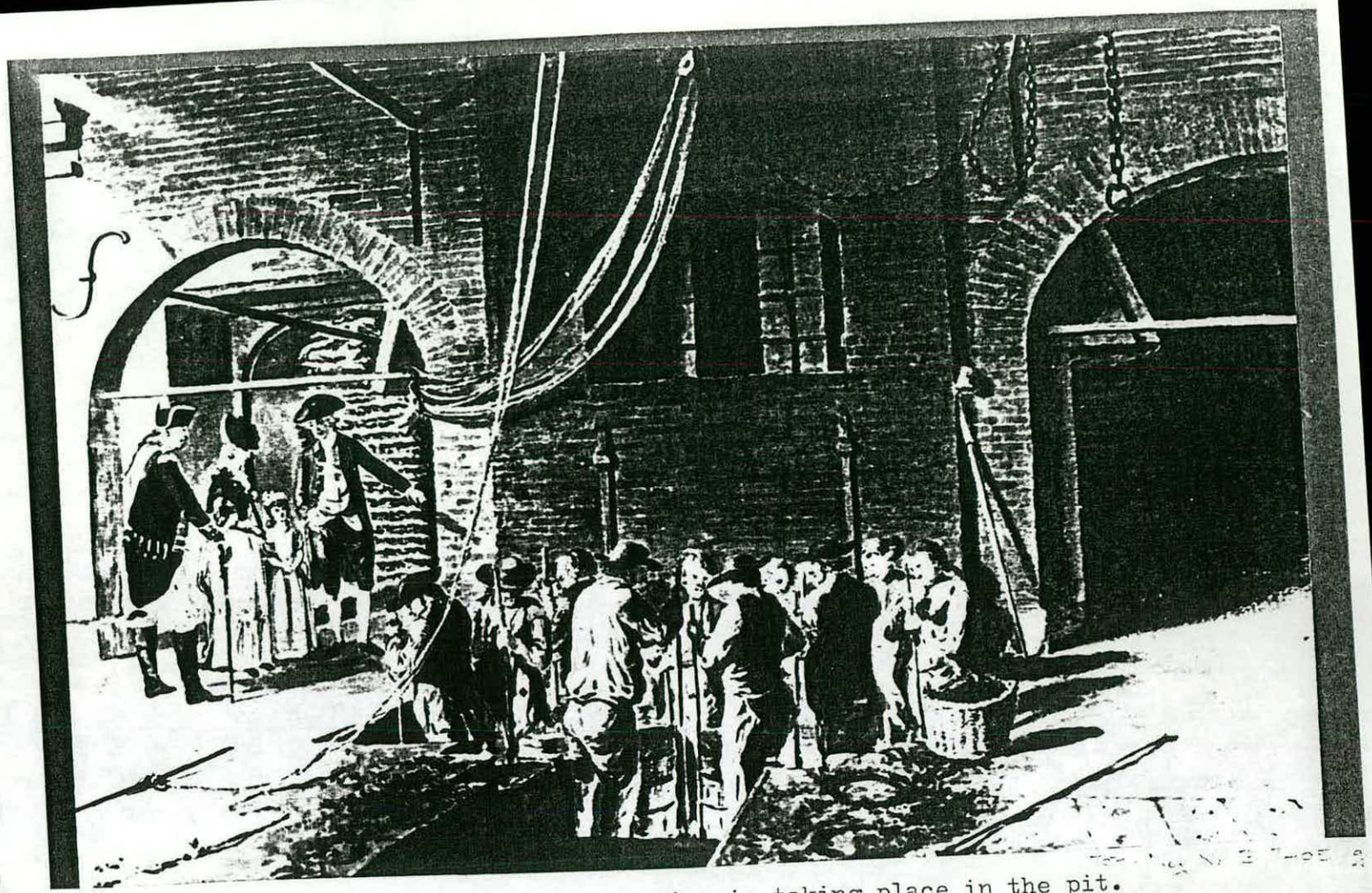




27. Seven cascabel moulds are being baked on the left. A charcoal fire burns within as well as under the moulds.

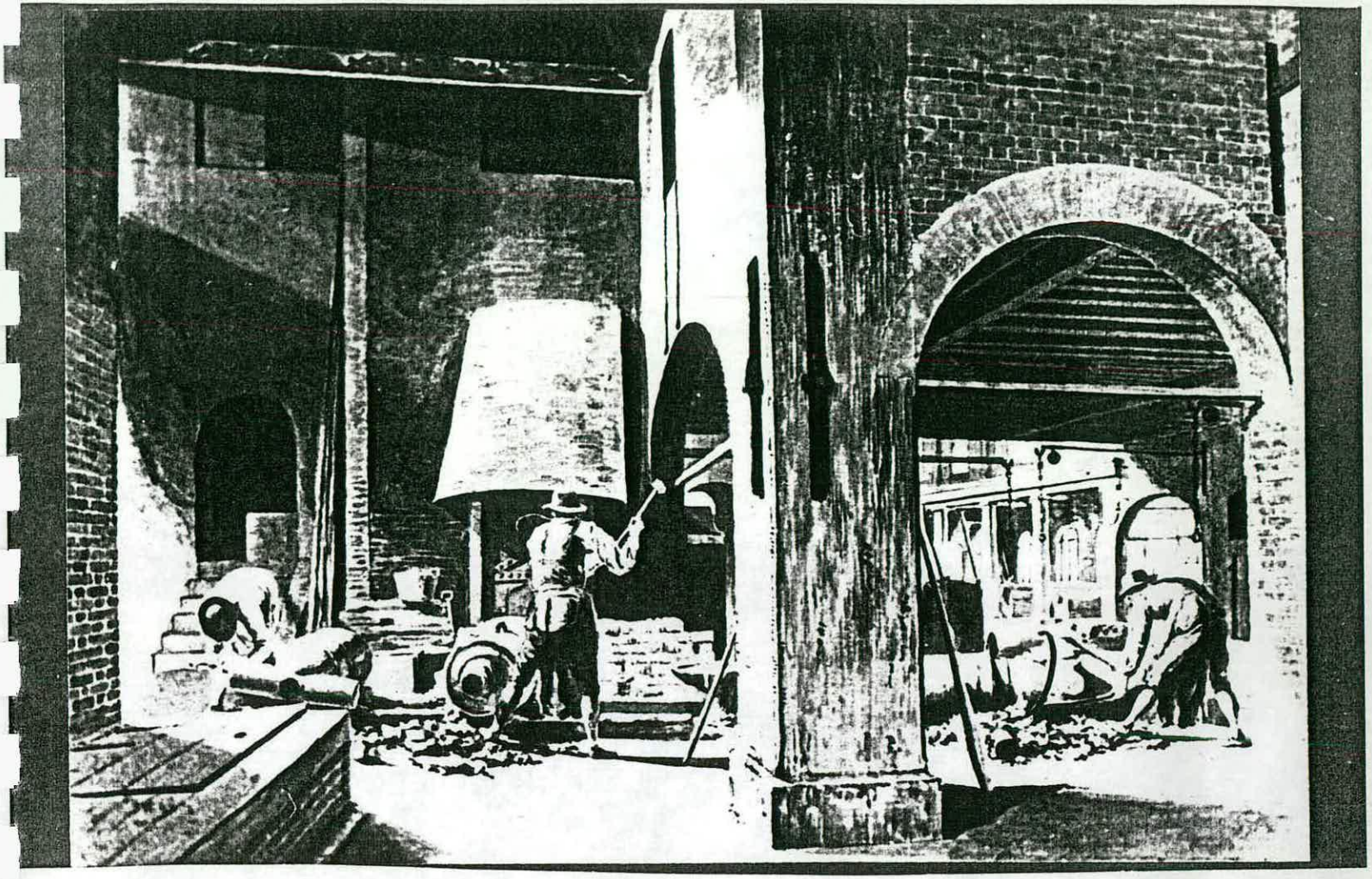


30. The worker on the left is rigging iron strapping above the cascabel mould of a small-calibre gun.



33. Filling and compacting operation is taking place in the pit.

The figure on the extreme left was once though to be that of King George III who visited the Royal Brass Foundry in 1773, but is now thought to be the Master General of Ordnance, George Viscount Townshend, who visited in 1775.



42. A mortar and two howitzers are seen here being broken out of their moulds.

ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

London **NGR: TQ 440 793**

Greenwich **Buildings Index No: 92394**

The Royal Arsenal, Woolwich

Building 10 (The Royal Carriage Factory)

Summary

This workshop complex was the heart of the Arsenal's Royal Carriage Department. The first gun-carriage works on the site were built in 1728-9. Known as Carriage Square these were altered and extended in 1776-9. A fire in 1802 and the establishment of the Royal Carriage Department in 1803 to meet growing demand appear to have occasioned a rebuilding of the works as a larger factory, complete by 1805 when steam power was incorporated. However, fabric from the earlier building may survive. This factory was an exceptionally large and ordered group of engineering workshops for its time. It comprised a quadrangle of workshops and stores, with pavilions at the corners and a pedimented centre with a clock turret to the north, all enclosing open avenues around three parallel smitheries, each flanked by wheeler's shops. The outer brick elevations survive with relatively little alteration, except to the east. The north and south perimeter buildings largely survive. However, the core of the building has been rebuilt. In the late 1850s the inner blocks were linked and the avenues covered. The inner blocks were almost entirely replaced with a much taller single central workshop in 1937, reconstructed in 1967-8. In 1994 the building is vacant.

Report

Introduction and Background

The work of the Royal Carriage Department was to build the gun carriages and their wheels and mount the gun barrels onto them. The site of Building 10 was first developed in 1728-9 as what came to be known as Carriage Square, the quadrangular layout of which is shown on a plan of 1749. The buildings were erected by Sir William Ogborne, a carpenter, and

reportedly contained overhead travelling cranes.[1] In 1776 new workshops for smiths and carpenters were built. A plan of 1777 indicates that these were western extensions to Carriage Square, at the west end of the present site, fronting onto what is now Merbury Street. To the east a 'Repository for Military Machines' was added in 1778-9.[2]

A fire in May 1802 gutted the Repository, but it is unclear to what extent the main building was damaged and whether the 18th-century buildings were entirely swept away as a result. In the following year the Royal Carriage Department was established by Royal Warrant to enable an expansion in carriage-making capacity. This may imply wholesale redevelopment, perhaps part of a wider building campaign headed by Captain George Hayter, CRE, to meet the perceived threat from Napoleon.[3] Further detailed documentary research may clarify the precise nature and extent of the 1802-5 works. There was certainly an overhaul of working practices through mechanization. For example, in 1805 a steam engine and planing machine were ordered from Joseph Bramah, and in 1807 two reverbatory furnaces and a large circular saw followed.[4]

Description

The building is constructed of brick and is of a single storey except for the north range which is of two storeys. The window openings are a combination of round and flat headed and segmental arched, with some rubbed brick. Central to the north range three bays break forward under a clock tower and a triangular pediment. A tall arch here contains a window and appears never to have been fully open. On either side of it at the upper level there are oculi. In terms of architectural style the elevations are what might be expected at the turn of the 19th century, though a 1770s date can not be ruled out on this basis.

The present factory is in effect a large, covered, open space with buildings around its rectangular perimeter. Inside these outer ranges there is an avenue, formerly open but now roofed over, which borders an inner rectangular area. The central rectangular area is presently an open space interrupted only by the stanchions of a modern roof. It was formerly divided into cross ranges.

A plan of 1835 depicts the layout of the building at that time[5] and shows it to have been broadly reminiscent of agricultural buildings erected on model farms of the period. It details the use of the rooms within the perimeter buildings and it can be seen that they were mainly wheeler's and carpenter's shops. An inventory from 1806 seems to corroborate these uses.[6] The plan shows that two rooms labelled 'shed', central to the north and south sides, had open colonnaded fronts at that time. The southern one of these rooms still has these columns. Two rooms adjoining the north-west corner contained sawing and planing machinery. The room in the north-west corner housed Bramah's steam engine, presumably with a boiler house and a chimney. This must have driven the machinery within the buildings. This is the only one of the corner rooms which is single storey implying that it was a tall single-storey to house an engine on two floors - perhaps a beam engine. The other corner rooms are two-storeyed, as are the central rooms on the north and south sides. These upper rooms were used for storage. What was stored is not specifically noted except for the upper floor of the north, central room which is labelled on the plan as 'model room' and which would have contained the wooden shapes for casting. The forges were housed in three smith's shops positioned within the area contained by the perimeter rooms. Each shop contained 12 forges arranged in two rows of six and each forge had an anvil positioned each side of it.

The smith's shops were blind rooms with a door at each end and a pair of ventilators in the roof. They were adjoined on one side by the wheeler's sheds which were colonnaded, walk-in rooms. The central and west smith's shops had wheeler's sheds positioned on their west and east sides respectively with vice shops adjoining the other sides. The east smith's shop had its wheeler's shed on the east side with a tinman's shop and pressing shop to the west. Pairs of doors gave access to the wheeler's sheds from the smith's shop.

The perimeter buildings survive in skeletal form. The openings in these walls are various but are dominated by a series of tall arches. They are presently roofed with combination wrought- and cast-iron trusses but one wooden truss survives. It is situated on the south side in the perimeter building marked on the plan of 1835 as 'wheeler's shop'. It is a queen-post truss with joggled heads and bases to the posts. Each queen post carries an angled strut and another angled strut supports the principal below each lower purlin. The junctions of the principals and the tie are held with iron straps. This truss is of a style and scantling which suggests that it could be 18th century in date, though it might full well date from the reconstruction after the 1802 fire. The height of the truss confirms that the perimeter buildings were single storeyed except for the central ranges on the north and south sides. As has been noted the south-central room of the perimeter buildings retains its colonnaded south wall. The columns of this colonnade are of cast iron, tapering cylinders with a simple moulding at their heads. Of particular interest is the presence on the columns of bolting holes for brackets to carry drive shafting. However they are only 2m above the floor level which, if it has not been raised, may have been too low to allow for head-room. These columns may date from the introduction of steam power to the site in 1805. They were certainly present by 1835 when they appear on the plan of that date.[7]

There is evidence of the earlier structures contained within the present central buildings and it is possible to relate what survives to the divisions of the central range which formed the smith's shops in 1835. For example, the south doorway into the central smithy seems to survive. The opening has a depressed segmental arch springing from kneelers of rubbed brick. To each side of this opening, 6.5 metres away is a recess, as shown on the plan of 1835, either side of the central smithy doorway. The south doorway to the east smithy also seems to have survived, although now blocked, and the south-west corner of the same smithy is discernible. This early walling is of Flemish-bond brickwork whereas the later 19th-century walling is laid in English garden wall bond. The Flemish-bond brickwork provides evidence for the south walls of each of the three smithies which are shown on the plan of 1835. Where a little paintwork has come away it is possible to see that the colour of the Flemish-bond brickwork is yellow. The style of parts of these earlier structures may indicate that they antedate the 1802-5 rebuilding, originating perhaps in the works of the 1770s.

Mid-19th-century and later Alterations

A campaign of alteration can be dated to around 1856-7 which included 'closing in the ends of East Avenue' and opening up two carpenter's shops into the main avenue.[8] The Ordnance Survey map surveyed in 1864 shows the new layout.[9] It would appear that the central smithies had been retained but that the areas between them had been linked for use as fitters' and metal workers' shops. The evidence for this alteration in the present building probably lies in the secondary brickwork of the south wall of the smithies, which, as has already been noted, is laid to English garden wall bond. The avenues around the central rooms were covered for use as wheeler's and carpenter's shops. The south-east and south-west corner rooms had by this time been converted to engine and boiler houses. Whilst the north-west

engine house probably retained its chimney, flues from the new boilers are likely to have vented through a chimney, octagonal in plan, positioned against the centre of the south wall. The biggest alteration in the 1850s phase was the sweeping away of the east wall and the carpenter's shops there to make way for a scrap forge (now Building 10D). The building was also extended eastwards by the addition of a wheel factory.

There are three types of 19th-century metal roof trusses used to cover the building. Trusses composed of flat iron straps, over the perimeter buildings; trusses composed of L-section cast-iron members with wrought-iron rods which meet in an oblong block at the base of the king rod; and similar trusses which meet in a circular hub and have a longitudinal member. The latter of these covers most of the former avenue area between the perimeter ranges and the central smithy area. The relative dates of these individual truss designs is not clear. However, drawings held in the Public Record Office imply that successive campaigns in the 1870s and 1880s gradually reroofed the avenues raising their height.[10]

What is also clear from these drawings is that the central range was not cleared of cross partitions before 1876. Indeed a small plan published in The Engineer for October 1891 indicates that the central area was still divided at that date.[11] The Engineer reported that the central area was used for steam rivetting and contained 'a very large lathe capable of turning a circle 27ft. in diameter'.[12]

The central area was apparently entirely rebuilt in 1937 as a single space more than doubling its height.[13] Extensive work was carried out to the building in 1967-8 including a refurbishment of the central area.[14]

Notes

1 - Brigadier O. F. G. Hogg, The Royal Arsenal: its Background, Origin, and Subsequent History, 2 vols, 1963, map facing p. 274 and pp. 283-4.

2 - Ibid, map facing p. 451 and pp. 462-6.

3 - Ibid, pp. 497-508.

4 - Brigadier O. F. G. Hogg, 'The Development of Engineering at the Royal Arsenal', Newcomen Society Transactions, xxxii, 1959-60, p. 35.

5 - Public Record Office, WORK 43/1517 (plan of the Carriage Department, 1835).

6 - Hogg, p. 545.

7 - PRO, WORK 43/1517.

8 - Hogg, p. 771: for a description of the work in the building in this period see The Quarterly Review, Jan.-April 1858, pp. 258-9.

9 - PRO, WORK 43/501 (Ordnance Survey map, 1866).

10 - PRO, WORK 43/1329, 1331,1642, 1643 (drawings of alterations, 1870 to 1885).

11 - The Engineer, 2 October 1891, p. 269.

12 - The Engineer, 2 October 1891, p. 270.

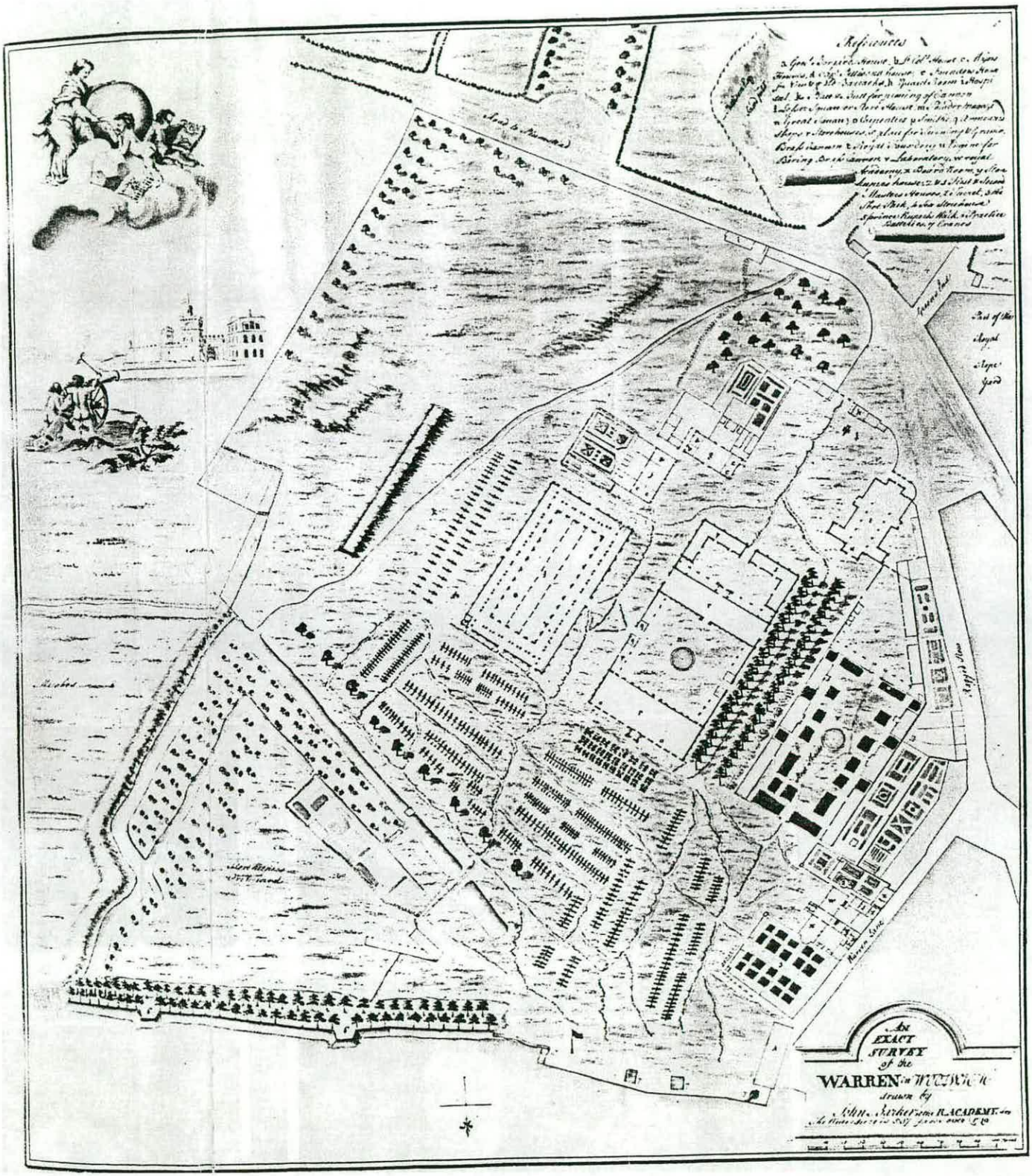
13 - Hogg, p. 1019.

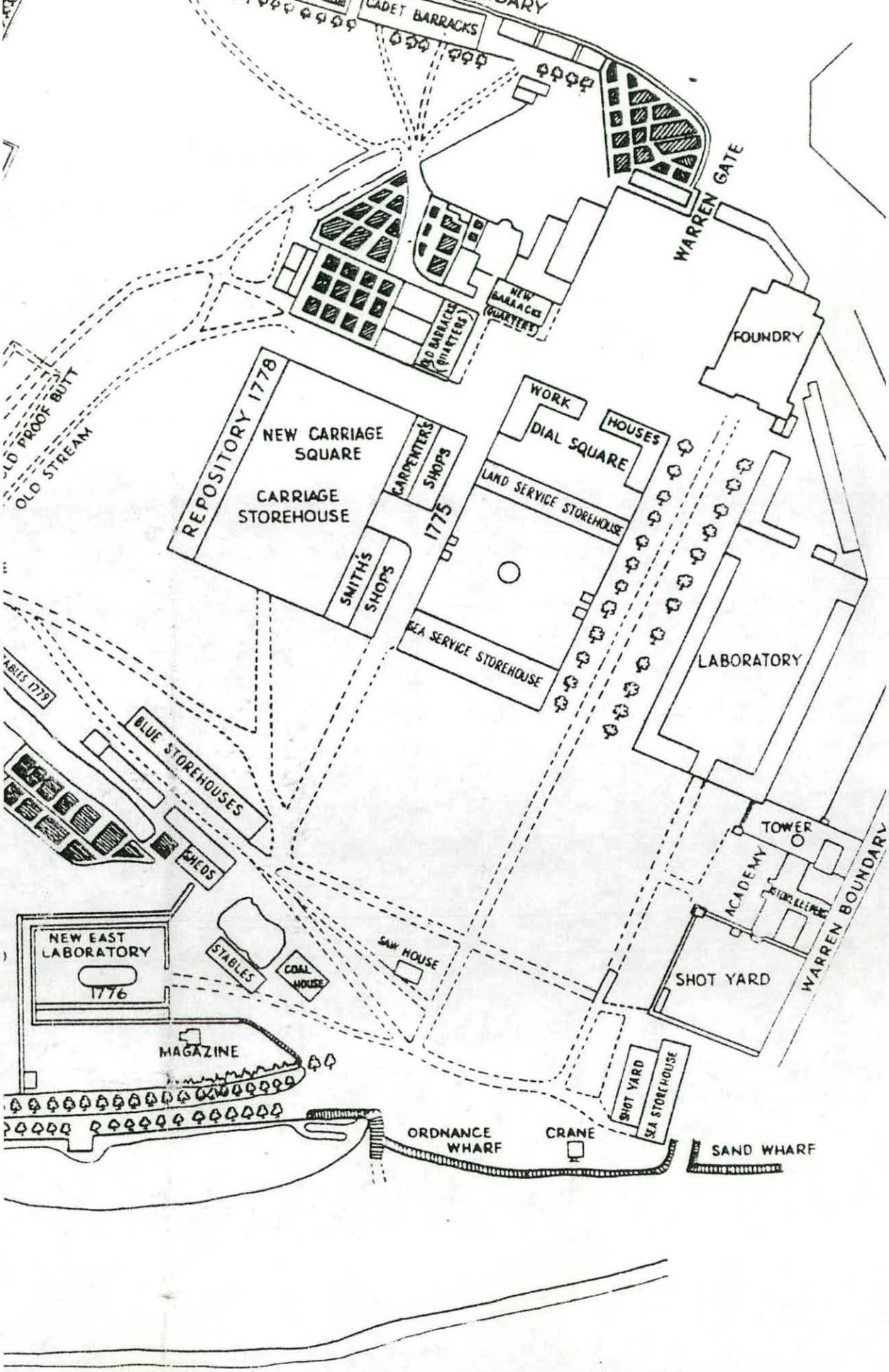
14 - National Monuments Record, PSA Collection G12049/11-12 (1967).

Recorded by Anthony Calladine and Derek Kendall, June 1994

Report by Anthony Calladine, October 1994

LIST OF ILLUSTRATIONS


References
An EXACT SURVEY of the
WARREN in WOOLWICH
drawn by
JOHN



PLAN OF WOOLWICH WARREN

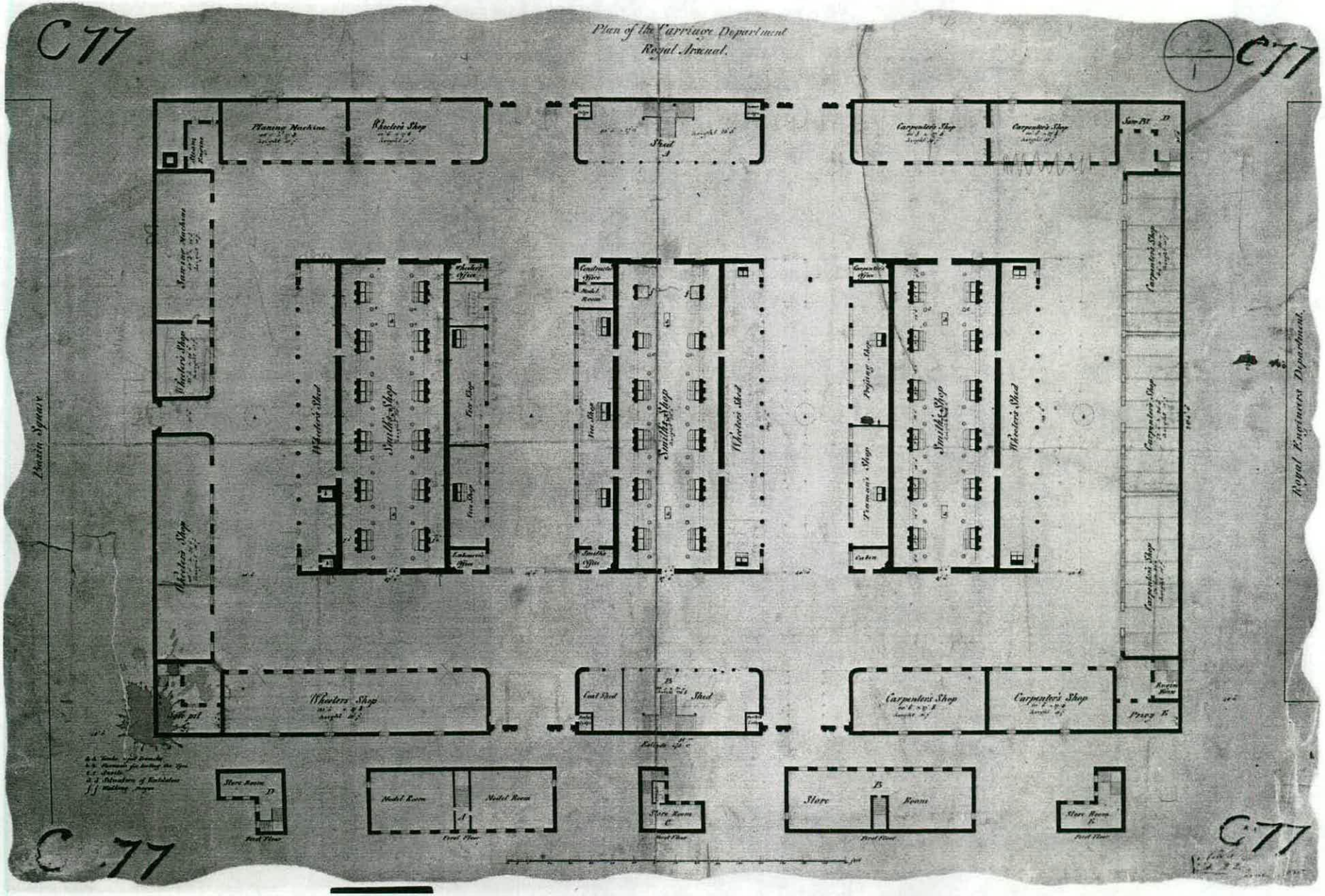
and the additional land purchased from Sir Thomas Wilson by the Board of Ordnance.

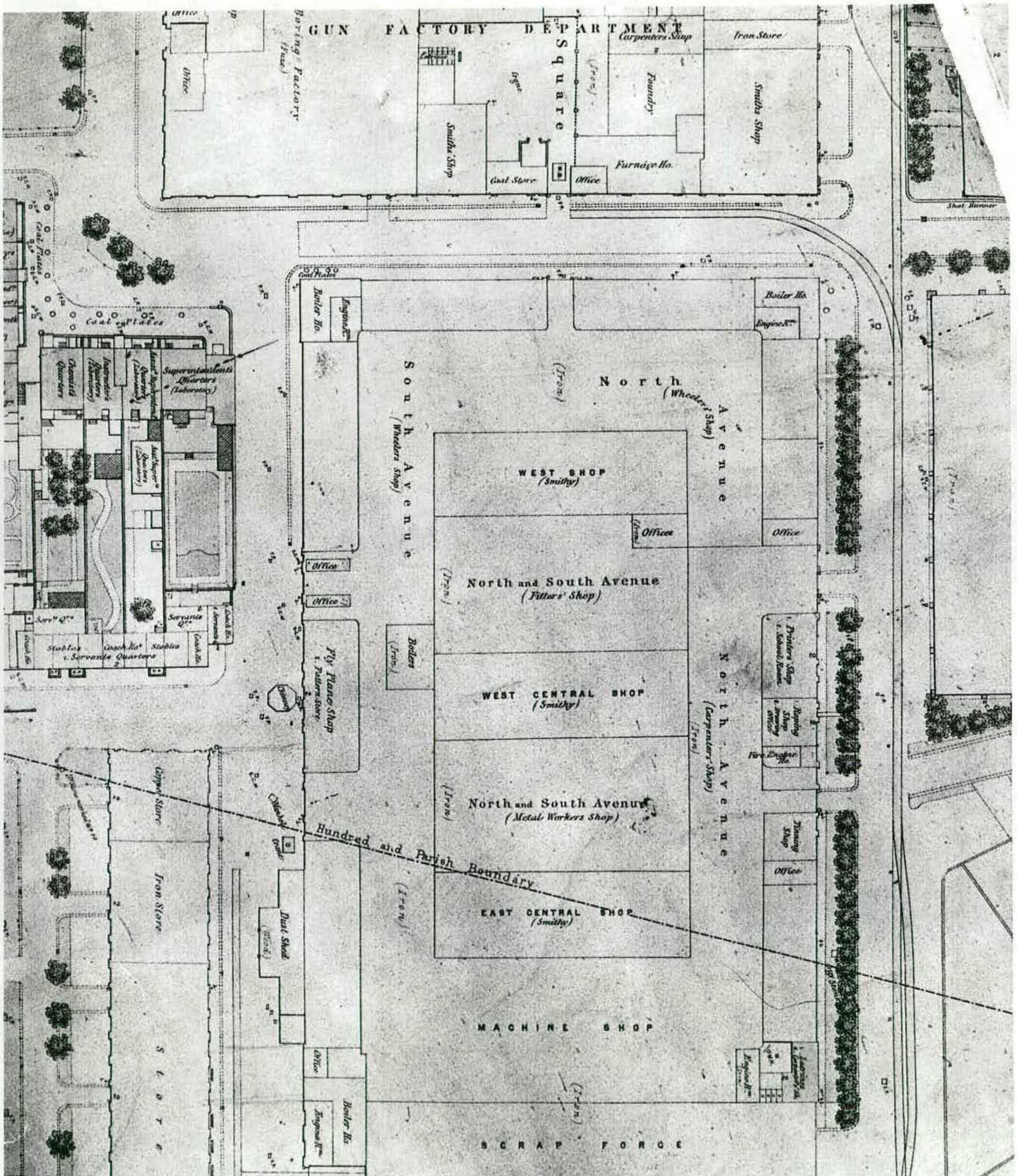
1777

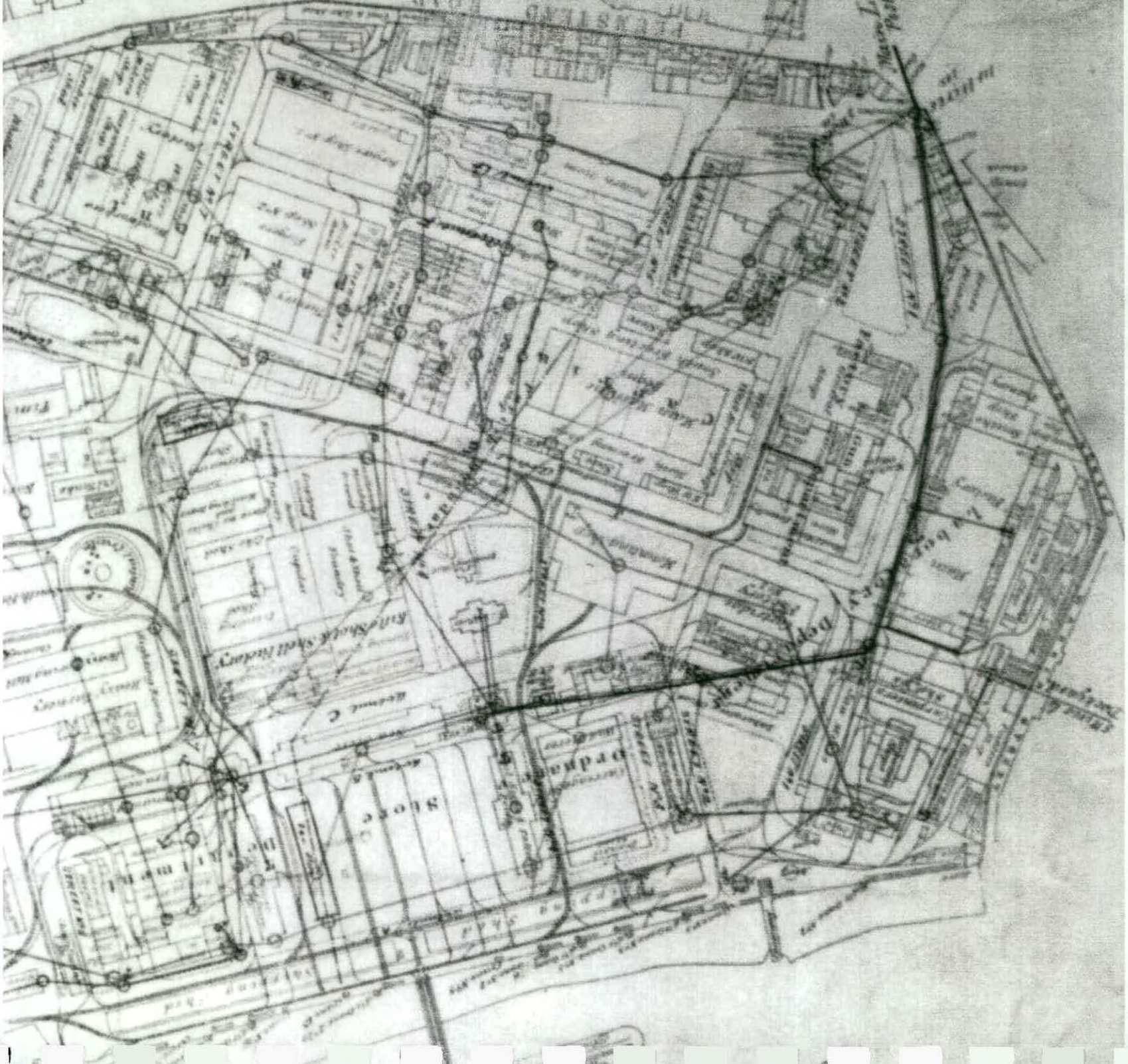
Site for the purpose of making a new Proof Butt and Stockhouse

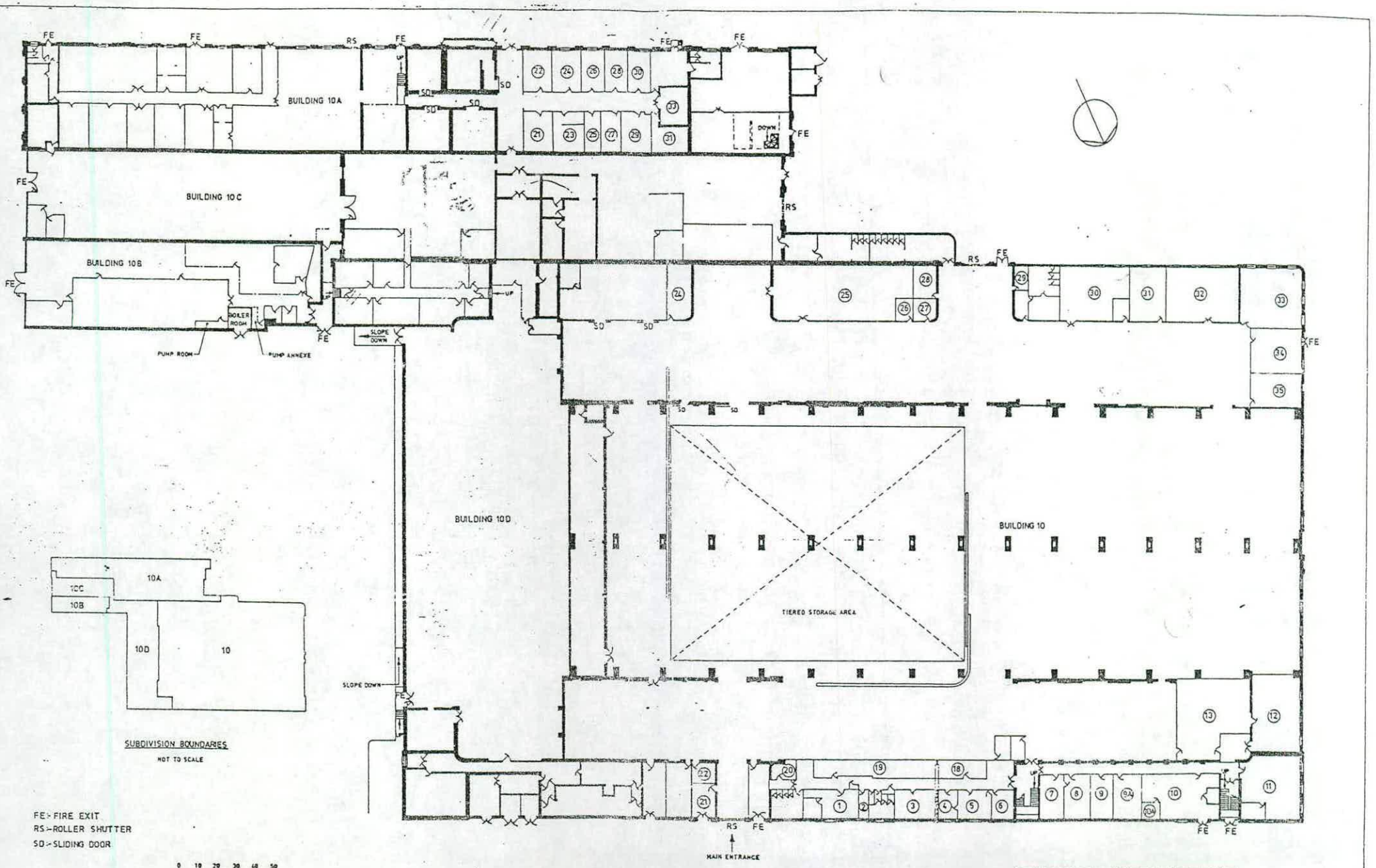
Scale :– 100 Feet to the inch.


Rope Yard
New Laboratory Square
Carriage Square
ROY
ARSE


C 77
Plan of the Carriage Department
Royal Arsenal.
C 77
Basin Square
Royal Engineers Department
Planing Machine
Wheelers Shop
Shed
Carpenters Shop
Carpenters Shop
Saw Pit
Steam Engine
Sawing Machine
Wheelers Shop
Wheelers Office
Wheelers Shed
Smiths Shop
Iron Shop
Iron Shop
Labourers Office
Wheelers Shop
Construction Office
Model Room
Iron Shop
Smiths Shop
Wheelers Shed
Smiths Office
Carpenters Office
Carpenters Shop
Forging Shop
Painters Shop
Smiths Shop
Wheelers Shed
Cabin
Carpenters Shop
Carpenters Shop
Carpenters Shop
Wheelers Shop
Sheds
Coal Yard
Shed
Carpenters Shop
Carpenters Shop
Sawing Machine
Privy
Store Room
Model Room
Model Room
Store Room
Store Rooms
Store Room
First Floor
First Floor
First Floor
First Floor
First Floor
C 77
C 77


GUN FACTORY DEPARTMENT
Boring Factory
Office
Square
Carpenters Shop
Iron Store
Foundry
Smiths Shop
Smiths Shop
Furnace Ho.
Coal Store
Office
Shot Runner
Coal Plates
Boiler Ho.
Engine Rm.
Boiler Ho.
Engine Rm.
Superintendents Quarters (Laboratory)
South Avenue (Wheelers Shop)
North Avenue (Wheelers Shop)
WEST SHOP (Smithy)
Offices
Office
North and South Avenue (Fitters' Shop)
Office
Office
Boilers
Fly Plate Shop & Pattern Store
WEST CENTRAL SHOP (Smithy)
North Avenue (Carpenters Shop)
Printers Shop & School Room
Fire Engine Ho.
North and South Avenue (Metal Workers Shop)
Hundred and Parish Boundary
Office
Iron Store
Dust Shed
EAST CENTRAL SHOP (Smithy)
MACHINE SHOP
Store
Office
Boiler Ho.
Engine Rm.
SCRAP FORGE
Fitters' Shop
Brass Foundry
Stables & Servants Quarters
Coach Ho.
Servants Qrs.





SUBDIVISION BOUNDARIES

NOT TO SCALE

FE:- FIRE EXIT
RS:- ROLLER SHUTTER
SD:- SLIDING DOOR

0 10 20 30 40 50
FEET

NOTE:-
THIS DRAWING REPRESENTS THE GENERAL LAYOUT OF THE BUILDINGS/ROOMS/FLOOR SPACE. WHEN ACCURATE ANALYSIS OF AVAILABLE SPACE IS REQUIRED MEASUREMENTS SHOULD BE CHECKED.

GROUND FLOOR

FIRST FLOOR
(OVER ROOMS 7 TO 16)

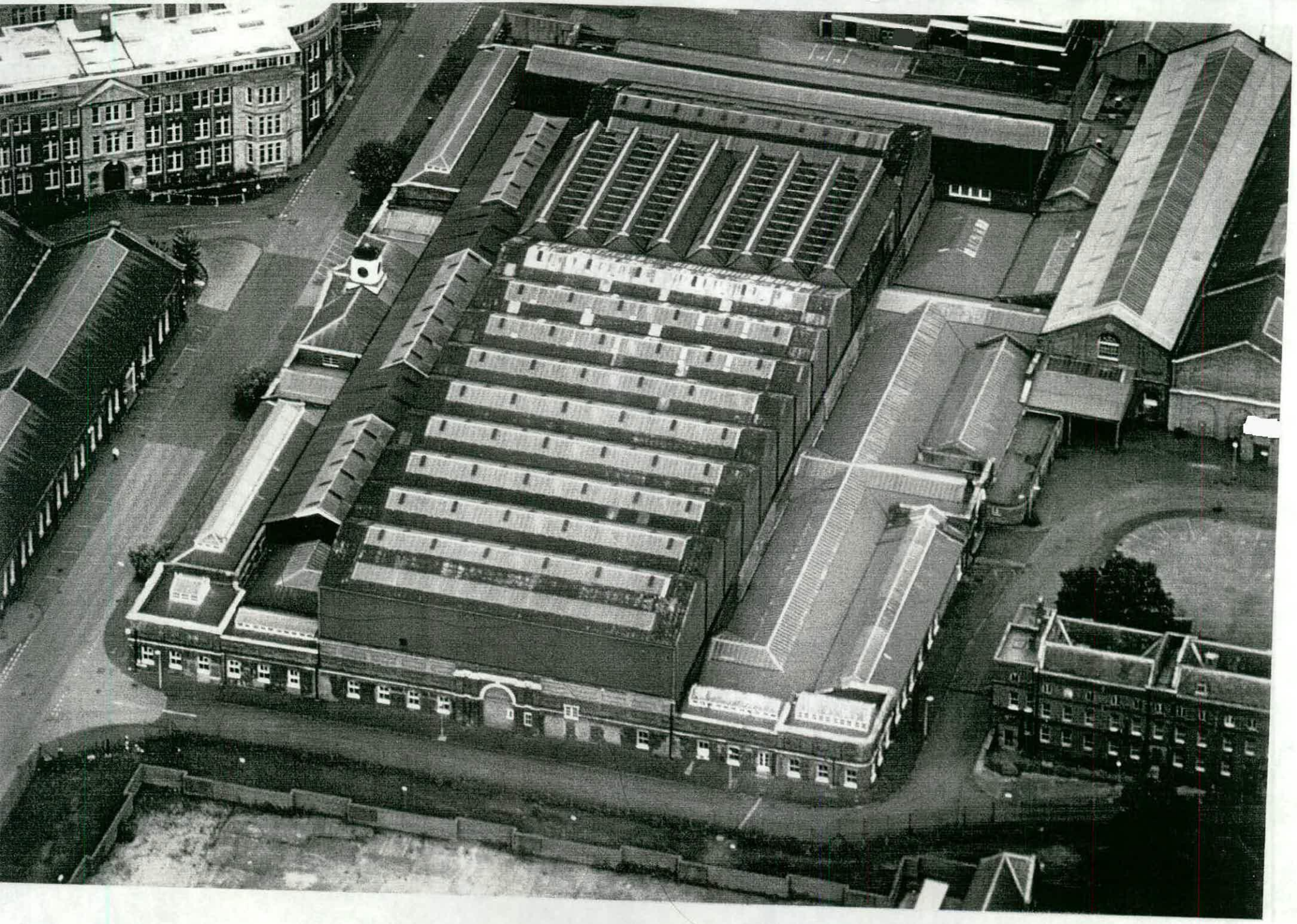
ROYAL ARSENAL WEST

BUILDING 10, 10A, 10B, 10C AND 10D

O.C. APP.			
DRAWN	HULTHORP		
ORIG SCALE	1 IN = 15FT		

BLD 10A AMENDED		5	5.10.70
BLD 10 & 10B AMENDED		4	15.6.63
REDRAWN & UPDATED		3	14.2.44
PARTITIONING ADDED TO BLD 10B		2	23.1.70
CHANGE	MOD NO	ISS	DATE
CERTIFIED		1	
DRAWING NUMBER	AQ-980-61455		

F




SMOKING
PROHIBITED.
STOCK ALLOCATION
FIRE


IRE EXIT

ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

London **NGR: TQ 440 793**

Greenwich **Buildings Index no: 92394**

Royal Arsenal, Woolwich

Buildings 36, 37, 46 and 49 (The Grand Store)

Summary

The Grand Store is an ambitiously conceived complex of storehouses with offices that originally fronted onto the river Thames. The complex was built around three quadrangles, of which only the principal centre quadrangle survives in anything like its original form. It was built for the Storekeepers Department of the Arsenal by the Board of Ordnance and was erected in stages from 1806-1813 during the Napoleonic Wars. The architect is unknown but the design has been attributed to James Wyatt, then Surveyor of the Ordnance, and his nephew Lewis. The brick and stone-dressed buildings are of two and three storeys to the central quadrangle; there were one- and two-storey ranges to the outer quadrangles. The three principal storehouses have timber-built interiors that are comparable to those of commercial warehouses of the same period. Both architecturally and structurally the buildings are conservatively designed, representing the end of an essentially 18th-century tradition. The buildings, which had been erected on fir piles, started to suffer from subsidence almost immediately. This led to the demolition of parts of some ranges as early as 1828. They required partial rebuilding and repairs throughout their operational lives. The Grand Store served as a general depot for the army and navy for items such as entrenching tools and harnesses as well as gun carriages and shot and shells. In 1855 it became the headquarters of the Ordnance Store Department. The storage capacity of the complex proved insufficient, leading to the covering over of the outer quadrangles in 1856-8 and the erection of four ranges, including two storehouses built 1888-9 and c.1890, on the former shotyard of the centre quadrangle. The eastern quadrangle, which had undergone substantial alterations, was demolished by 1967. The western quadrangle, which was substantially rebuilt c1890, survives. Although disfigured by heating pipes, partially obscured by later buildings and in large measure derelict, the Grand Store buildings form the most complete survival of Royal Arsenal departments. They are also one of the most important and best preserved group of storehouses to survive from a period notable for the ambition and scale of its military and commercial architecture.

Report

Historical Background

A new storehouse complex for the Arsenal's Storekeeper's Department was apparently conceived in 1801[1], during the turbulent period preceding the outbreak of the Napoleonic Wars. The Storekeeper's Department, also known as the Respective Officer's Department or Civil Officer's Department did not serve the manufacturing departments, which maintained separated storage facilities through the early 19th century. The new buildings were probably intended to serve as a general depot for the Army and Navy given the scale and grandeur of the architecture; they represented a massive increase in storekeeping capacity at the Arsenal.

The original undated drawings of the Grand Store survive at the Public Record Office. As proposed the scheme comprised four ornamented two- and three-storey linked ranges with corner blocks to all sides of the central shot yard, the north range having six columns to the river, a central tower and ornamental gateways to the corner blocks. The outer quadrangles were mirrored compositions of one-storey east and west ranges with two-storey end towers, with the north and south sides closed by one-storey ranges. At the centre of the outer quadrangles there were small square one-storey buildings. All the buildings were to be constructed from brick with slate roofs, with the grander ranges having stone dressings. The interiors of the centre storehouses were apparently of a uniform timber construction, indicating that they were probably not intended for specialist storage. It is unclear who was responsible for the designs, although they are usually attributed to James Wyatt, who was Surveyor to the Ordnance from 1782/3 to 1810, and his nephew Lewis. The chosen site was already occupied by several buildings, notably the East Laboratory of 1776 and a carpenters' shop, all demolished in 1806-7.

In estimating the costs of the scheme Captain Hayter, the Inspector of Building Materials and Tools, suggested £237,000 for the superstructure alone. This was a huge sum at this date indicating the ambitiousness of the scheme.

Although the location of the buildings was convenient for distribution its marshy site presented certain constructional difficulties. The three years following the initial proposals appear to have been spent in discussions about the most appropriate method for achieving secure foundations for the buildings. In 1805 Lieutenant-General Morse, Inspector General of Fortifications, recommended driven piles and fir piling was started immediately. The construction of the central quadrangle began in 1806 under the supervision of Mr Brock, formerly Clerk of the Works at Chatham. The west quadrangle was started in 1809 and the east quadrangle in the following year. During 1810-11 it was decided to omit purely decorative features such as the ornamental gates, presumably on grounds of cost. It appears that the north range of the main quadrangle had also been scrapped by this time. In 1811 it was decided to add an extra storey to the east and west ranges of the outer quadrangles for additional capacity. By 1813 the buildings were effectively complete. In their general arrangement the buildings were in the tradition of the late 17th century and later storehouses in the Naval Dockyards at Woolwich, Chatham, Devonport and Portsmouth[2]. Perhaps the closest parallel for the layout is with the Devonport storehouse complex of 1762 onwards, conceived as a double quadrangle with ranges linked by carriageways. In its timber internal construction the Grand Store has parallels in commerical buildings such as the East India Company's 1790s warehouses at Cutler Street and the West India Dock North Quay warehouses of 1800-3. These buildings are at the end of an essentially 18th-century tradition, uninfluenced by the introduction of fireproof construction methods, notably the use of structural iron.

The next generation of military storehouse complexes such as the Quadrangle Store at Sheerness, started in 1822, the new storehouses at Deptford Victualling Yard, constructed in the 1820s, and the Royal William Victualling Yard at Plymouth of 1824-33, were built using cast- and wrought iron structural members[3].

Within two years of the Grand Store's completion cracks were noted in some of the buildings. This was thought to have been caused by subsidence resulting from the proximity of the river. Concerns about their deteriorating condition led, in 1822, to a condition report and the authorisation of the first repairs, carried out on the principal storehouses. By 1828 the condition of the east corner block of the centre quadrangle (Building 37) was so dangerous that it had to be emptied and the north wall taken down; an estimate of £7154 was submitted for new foundations. The following year the north range of the east quadrangle was demolished. The structural problems appeared so severe and widespread that a complete rebuilding was considered and in 1832 a special committee was formed under Captain Duncan, Principal Storekeeper to the Office of Ordnance, to consider the future of the Grand Store. One option considered was moving the buildings elsewhere in the Arsenal but this was rejected. In defence of the Grand Store the committee found that ' at present they form an imposing structure, are conveniently sited, and are a credit to the Naval and Military reputation of the country in compensation for their great cost'[4]. Before the committee reached its conclusions further demolition was required in 1833, including parts of the main storehouse. In fact, no overall resolution of the problems was achieved and the committees recommendation that £50,000 to £60,000 be spent on re-establishing the foundations was never acted on. Instead, a piecemeal approach of repair and underpinning, or when necessary demolition, seems to have been adopted.

In 1825 the first attempts at reforming the inefficiencies of the Arsenal's several storekeeping systems were made. In 1849 a more effective centralisation of the Arsenal stores was realised, with all stores, including raw materials and finished goods, and presumbly all store buildings coming under the Storekeeper's authority. The storage facilities of the Arsenal were insufficient to judge by the conclusions of a report of 1852. This found that many of the buildings had been attacked by worms, space was taken up by piles of obsolete stock and storage space for guns and carriages was generally lacking. Consequently, in 1854 it was proposed that the outer quadrangles be covered over at a cost of £18,000 and the north range of the east quadrangle rebuilt. Before this work started the Storekeeper's Department underwent further administrative change when, following the abolition of the Board of Ordnance in 1855, the Arsenal became the headquarters of the retitled Ordnance Store Department. The building work was carried out between 1856-8. In the following decades the reformed Ordnance Stores of the Royal Arsenal reached the height of its importance as "the great central depot . . . of the Empire for the receipt, inspection, primary custody and first issue of Army stores"[5].

In 1887-9 the entire Royal Arsenal was transformed administratively by the implementation of the Morley Reforms. As a consequence the Ordnance Stores were re-established as the Central Stores Branch although the impossibility of erecting a central storage depot of sufficient size at the Arsenal meant that the reforms were apparently largely adminstrative. However, extra capacity was achieved by the construction of two new large warehouses (Buildings 47 & 48) on the former shot yard in 1888-9 and c1890 respectively. This was later increased by two more ranges probably built in the early 20th century. The headquarters of the Army Ordnance Department, successor to the Central Stores, remained at Woolwich until 1904.

The long decline of the Grand Store appears to have begun in earnest in the years following the First World War, although the eastern quadrangle had been largely replaced by a central power station as early as 1908. Two of the later ranges in the central quadrangle were demolished in the mid 20th century. It is unclear at what date the more structurally unsound ranges of the central quadrangle were abandoned, though it is possible that it may have been before 1931. However, by the time of the closure of the Ordnance Factory in 1967 the the east range (Building 49) and corner block (part of Building 36) and the east half of the south range (Building 36) were in an advanced state of decay. The remaining buildings, the west range (Building 46) and corner block (Building 37) and the west end of the south range, have remained at least partially in use up to 1994.

Although the ambition and grandeur of the Grand Store cannot be doubted functionally it can only be counted a costly failure. The inadequacy of the buildings to the site was underlined throughout the 19th century by severe structural problems. The costs of construction, as well as the expense arising from these problems, are possibly incalculable and certainly immense.

Building Description

The following descriptions are of the surviving buildings of the central quadrangle. For the west quadrangle see the separate 'rapid survey' report on Building 45.

West Storehouse, Centre Quadrangle (Building 46, pre-1967 Building B40)

This range appears to have been built in 1807-13, the second of the great storehouses to be erected. It was described in the Ordnance book of 1811 as being one of the 'stores

of different descriptions' but by 1851 it was noted as an entrenching tool store. By 1888 it was less specifically designated as a tool store. The two-storey building is constructed of brick with Purbeck-ashlar angle pilasters, cornice and plinth, and a slate roof. The building is 65m by 13.5m (213 ft by 45 ft) with identical fifteen-bay east and west elevations and three-bay elevations to the north and south. To the east and west the three pedimented bays step forward to the centre, a design found elsewhere in the Arsenal, notably in the contemporary ranges of New Laboratory Square. The round-headed windows of the ground floor are set in gauged brick arches. The surviving sash windows are replacements of the original timber sashes, the absence of iron indicating that the security of the stores was not a particular concern. Some windows have been unsympathetically replaced in the 20th century. The north elevation retains its original rusticated stone porch to the centre entrance bay. The porch has been reroofed and the original vaulting removed. To the south there is a vaulted carriageway link with a bridge over, with a rusticated central arch and two square-headed pedestrian openings. This design is repeated to all of the carriageways, although all have been altered and only three of the original four survive. This carriageway is the only one to retain any of the original groin vaulting; it survives to the north end. The bridge was originally uncovered but has been roofed, with brick walls with stone dressings replacing the original stone balustrade. This was probably done at the time of the conversion of the first floor of the west range (Building 46) into offices, between 1890 and 1931. The exterior of the building is in good condition, some sympathetic rebuilding has taken place to the south return of the centre bays on the west elevation, but all fittings relating to its warehouse origins have been removed. From the exterior of the less altered eastern range (Building 49) it appears that the loading of goods was through the centre doorways on all elevations. The east range also has a first-floor loophole to its east elevation, but

surprisingly there is no evidence of an equivalent bay to the west range.

The interior of the building is divided into three, with a five-by-three bay section flanked by six-by-three bay sections. The original internal timber construction survives relatively unaltered to the north on the ground floor. There are two rows of 30cm sq chamfered posts with cushion caps and stone bases, the latter now covered by concrete. These support two axial beams, with scarf joints to the centre of their approximately 33m (80ft) length, and twelve unjointed cross-axial beams, approximately 18m (45ft) long, in turn carrying the floor joists. The structure is reinforced by iron bolts passing through either side of the cushion capital, axial beam and spreader of the first-floor post. The whole frame is constructed on a 4m (13 ft 6inches) grid. The brick party wall has three large arched openings to allow for the free movement of stores. Surprisingly none of the openings appears ever to have been blocked as a fire containment precaution, as is found elsewhere in the storehouse ranges. In the first floor a shallow brick arch with a trimmer joist abuts the party wall, perhaps indicating a former fireplace and thus perhaps an office in the centre section. Although the ground-floor posts of the middle section survive, running east to west as opposed to those in the outer sections which run north to south, they have mostly been encased in modern partition walls. Modern stairs in the north west bay may occupy an original stair position, as there is evidence of a corresponding stair in the east range. The original framing of the north section also survives on the first floor, obscured by subdivision and an inserted ceiling. The first floor appears to have been converted into offices, an extension of the offices to the south corner block (Building 45) after 1890 but before 1931. The south section has been rebuilt internally throughout, with reinforced-concrete framing replacing timber, for the conversion of the ground floor into offices in the mid 20th century.

Offices, West Corner Block, Centre Quadrangle (Building 37, pre-1967 Building B45)

This building was erected in 1806-13, part of the first phase of work with the central storehouse. It was built as three-storey offices for the 'Respective Officer's Department', as the Storekeeper's Department was sometimes known. The 22m (71ft) square Greek Cross plan with three-bay ends is identical to that of the east tower, which was built as store. It is constructed of brick, with Purbeck ashlar angle pilasters, plinth and cornice, rebuilt to the upper storey. The renewed slate roof has a sqaure lantern with stone balustrading, originally with brick chimney stacks to the corners. The round-headed sash windows are set in arched recesses to the ground floor with segmental heads to the upper floors. The centre bay of the south elevation, which is ornamented by a stone surround for its full height, has had its original window openings altered. More significantly, the centre window in the ground floor may originally have been a doorway, as is the east corner block. If so, then the alteration would date from 1863, when Milnes' statue of the Duke of Wellington was set up immediately to the south. The statue, which was moved in 1974, formed a group with the First World War memorial still sited in the return bays of the south and east elevations. The pedimented stone tablet is dedicated to the men of the Ordnance Department, with a small flower border edged by reused gun tracks dated 1858 from the Royal Gun Factory. On the north side the pedestrian bay of the carriageway has been enclosed to form a small extension. The main entrance was to the east. The originally identical east carriageway and bridge has lost its original vaulting and the refloored bridge has been roofed with scissor braced timber trusses covered by corrugated sheeting. The original stone balustrading survives.

The layout of the building has offices on all floors, ranged around a large open square core. The plan is essentially identical to the west storehouse tower, the retention of symmetry apparently taking precedence over practicality in the design of the complex. This it is an early example of a purpose-built multi-storey office block. The entrance hall is an impressive space, has a roof lantern and cantilevered open-well stair rising its full height. The original stair has stone treads with iron stick balusters; the stair soffit has been reinforced with steel girders. The bottom step, originally wreathed, has been squared off. In the centre of the space a 19th-century cast iron stove may survive, concealed by a protective box[6]. The remaining fireplaces, partitions and joinery are simple, and in some instances have been replaced. Chunky moulded screens in the large arched openings to the east and north on the ground floor, appear to be a late-19th-century insertions. The second floor, roof and lantern have been repaired in the mid-to-late 20th century.

South Storehouse, Centre Quadrangle (Building 36, pre-1967 Building B38)

This storehouse, the largest and most ornamental of all the ranges, was the centrepiece of the whole composition and the first part to be built. It was constructed from 1806-1813 on a Dundee stone plinth. The three-storey building originally fronted an open shot yard, leaving its entire 94m (312ft) length visible from the river. The twenty-three bay north and south elevations have three-bay centre sections and projecting three-bay pavilions to each ends. Like the other ranges it is built of brick with Purbeck ashlar dressing. To the north the projecting bays of the east pavilion are faced in ashlar, probably the result of subsidence repair and rebuilding to the building in 1822 and in 1833. The west end of the range has been altered, probably in the late 19th century, when the north loading bay was internalised, and the loopholes were reduced to form

windows. At the same time the ground-floor doorway on the south elevation was also reduced to a window. However, the east end retains its original arrangement to north and south, with loading bays to both floors retaining mid-to-late-19th-century wall cranes. The carriageway and bridge to the east, as on the west side, has been roofed over in corrugated sheeting and the original vaulting removed. A late-19th-century lean-to toilet has been built against the east wall, blocking the former doorway.

In plan the building is divided into five, a centre section of three bays with two sections of five bays and the outer pavilioned sections of five bays. Both end sections form a Greek Cross. Much of the interior could not be inspected but it appears that originally the brick partition walls had three large arched openings at each level, apparently making each whole floor area intercommunicating. Most of these openings were bricked up in 1898 as a fire precaution; iron-plated fire doors, some with iron surrounds, were inserted into the remaining openings. In commercial warehousing insurers had been insisting on such fire precautions since the 1860s. Indeed, fireproofing does not appear to have been a particular concern with the Grand Store buildings. This and the distance of the centre block from the river may relate to use of the buildings for very long-term storage. When built the storehouse apparently held 'stores of different description'. At some point before 1851 the ground floor had become a Harness store, remaining so throughout the 19th century, and the upper floors were used as a Sea Store. By 1931 the ground floor was being used to store side arms and the upper floors tools. The interior of the building appears essentially as built apart from the insertion of a mezzanine floor in the middle section and two phases of alterations to the west. In the late 19th century a brick-walled internal loading bay was created to the north with a 15cwt crane. The whole area was subdivided and a mezzanine floor was inserted in the 1970s, following

the abandonment of the rest of the range. The internal timber construction is the same as in the west range (Building 46), and was probably uniform to all the storehouses. There is considerable evidence of attempts to reinforce the building, with the addition of heavy brick corbels or iron brackets to the cross-axial beams. On the second storey the posts support conventional queen-post roof trusses, probably the common arrangement to all the storehouses, although this was the only building in which the roof is accessible. The roof has been altered only by the addition of late-19th-century skylights with a related raising of the ridge. The pavilion bay roofs have been renewed, with steel joists strapped to the tie beams.

Storehouse, East Corner Block, Centre Quadrangle (Building 36, pre-1967 Building B38)

The east corner block was built on an identical plan to the west corner block (Building 45) in 1808-13. The building appears to have started to subside almost as soon as it was finished. In 1828 it had become so dangerous that it was emptied and the north wall was taken down, with the recommendation that new foundations be laid with 32ft piles. As elsewhere is brick built with Purbeck ashlar dressing. It retains more of its storehouse fittings than some of the other ranges, with a late-19th-century wall crane to the loophole on the south side and heavy wooden doors. The carriageway and bridge to the north were demolished sometime after 1888. The slate roof, with stone balustrading to the core, survives beneath a temporary corrugated-iron hat. In 1866 this block was described as the junk house, with saddle dye shop and dubbing loft. It was still in use in 1931, when it was used to store side arms, but its present condition would suggest that it was abandoned not long thereafter.

The interior could not be inspected, but the plan is as to the west corner block, with a square core open to the roof. All the cross walls here have central arched openings. There were stairs to north west.

East Storehouse, Centre Quadrangle (Building 49, pre-1967 Building B34)

Built in 1808-13, this was the last of the storehouses to be built. Originally it was identical to the west storehouse (Building 46) Like most of the Grand Store buildings on the eastern half of the site it appears to have suffered almost immediately from subsidence. It is unclear how long the building functioned as a storehouse, but no use is given for it on a map of 1931. The survival of a late 19th century wall crane to the east confirms that it was still in use at that point. In 1851 this was described as a land store, and by 1866 it was being used to store nails and harnesses. The west elevation has had a door inserted into its southernmost bay, an alteration of unknown date. The rusticated porch to the north survives but with its vaulting removed. The carriageway to the south was demolished after 1888. The structural condition of the building is unsound with scaffolding supporting the walls.

The building was not inspected internally. It appears that the centre section on the west side had a fireplace in the south-west corner suggesting that the room may have been used as an office. The north bay on the same side has a scar indicating the site of the stairs.

Notes

1- This and most other background historical information is taken from Brigadier O.F.G.

Hogg, The Royal Arsenal; its Background, Origin, and Subsequent History, 2 vols, 1963, pp. 523-536.

2- J. Coad, The Royal Dockyards 1690-1850, 1989, Chapter 6, Naval Storehouse, pp. 121-138.

3- M. Tucker 'Warehouses in Dockland', Dockland, 1986, pp. 21-8.

4- Public Record Office, WO/44/606, 'The Report of the Committee on the stores and storehouses in the Royal Arsenal',1833.

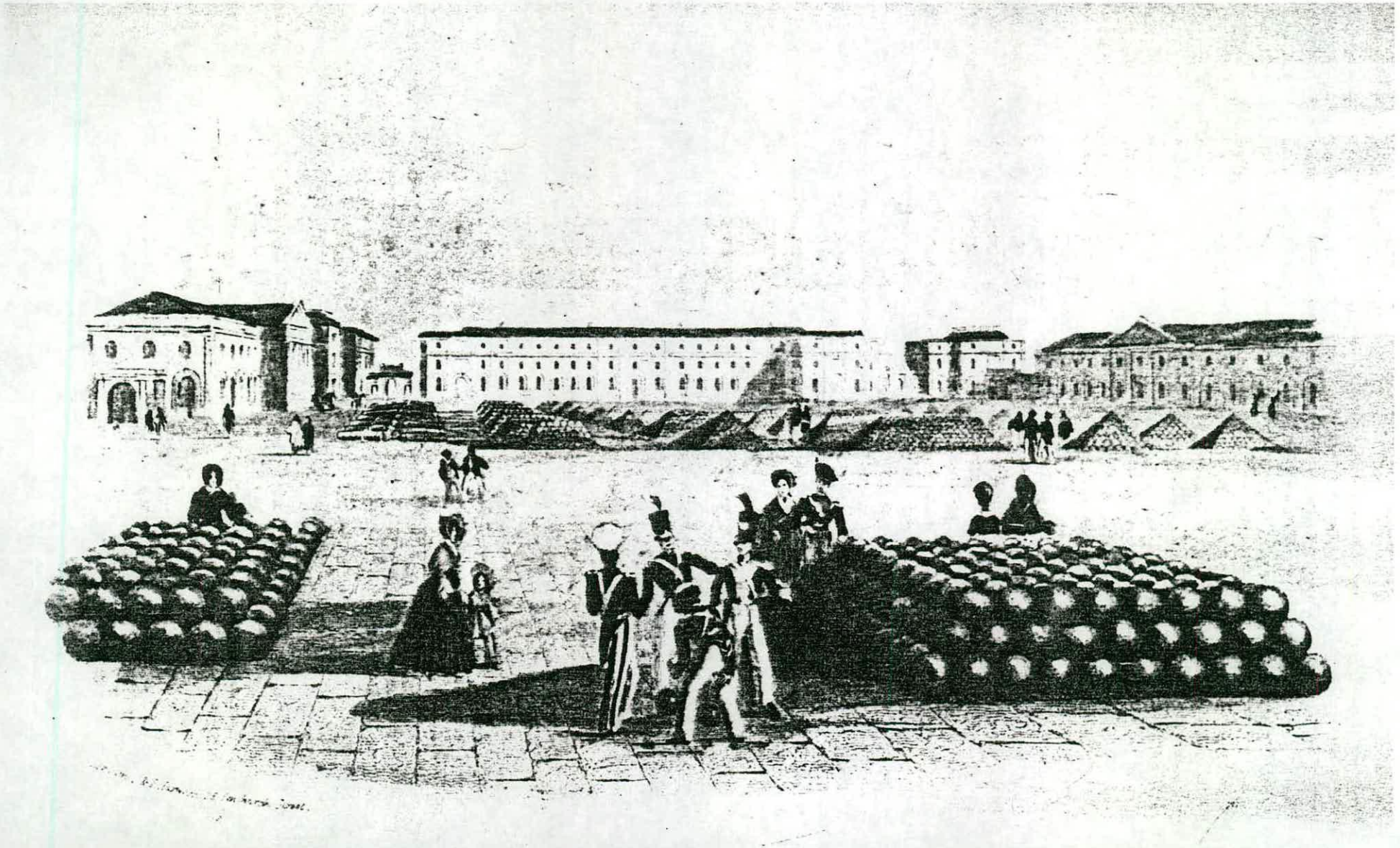
5- Select Committee report to the Secretary of State for War, 1888, as quoted in Hogg.

6- NMR photograph taken 1964 (BB64/1355).

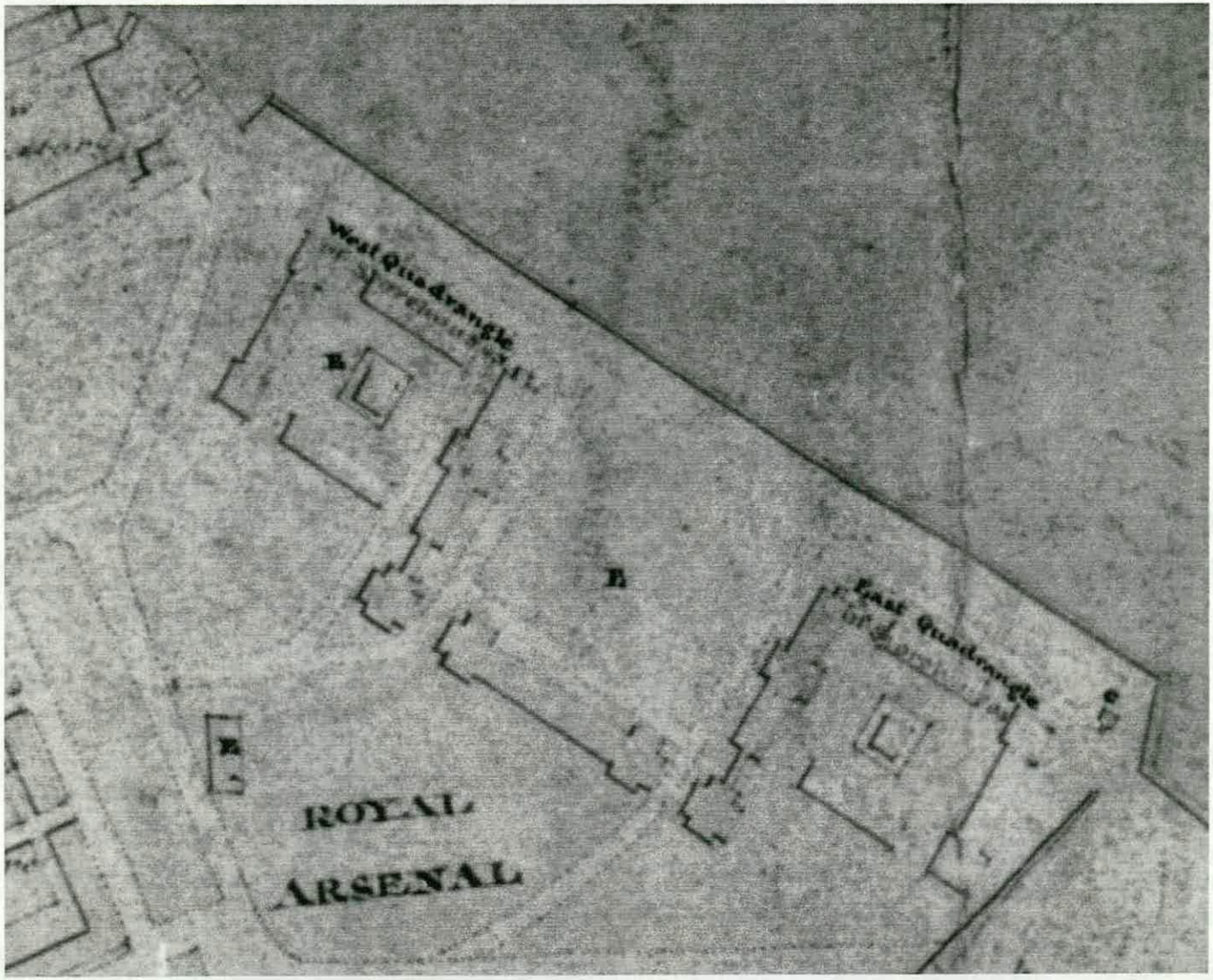
Recorded by Joanna Smith and Derek Kendall, June 1994.

Report by Joanna Smith, October 1994.

LIST OF ILLUSTRATIONS



The Royal Arsenal, 1847


West Quadrangle
East Quadrangle
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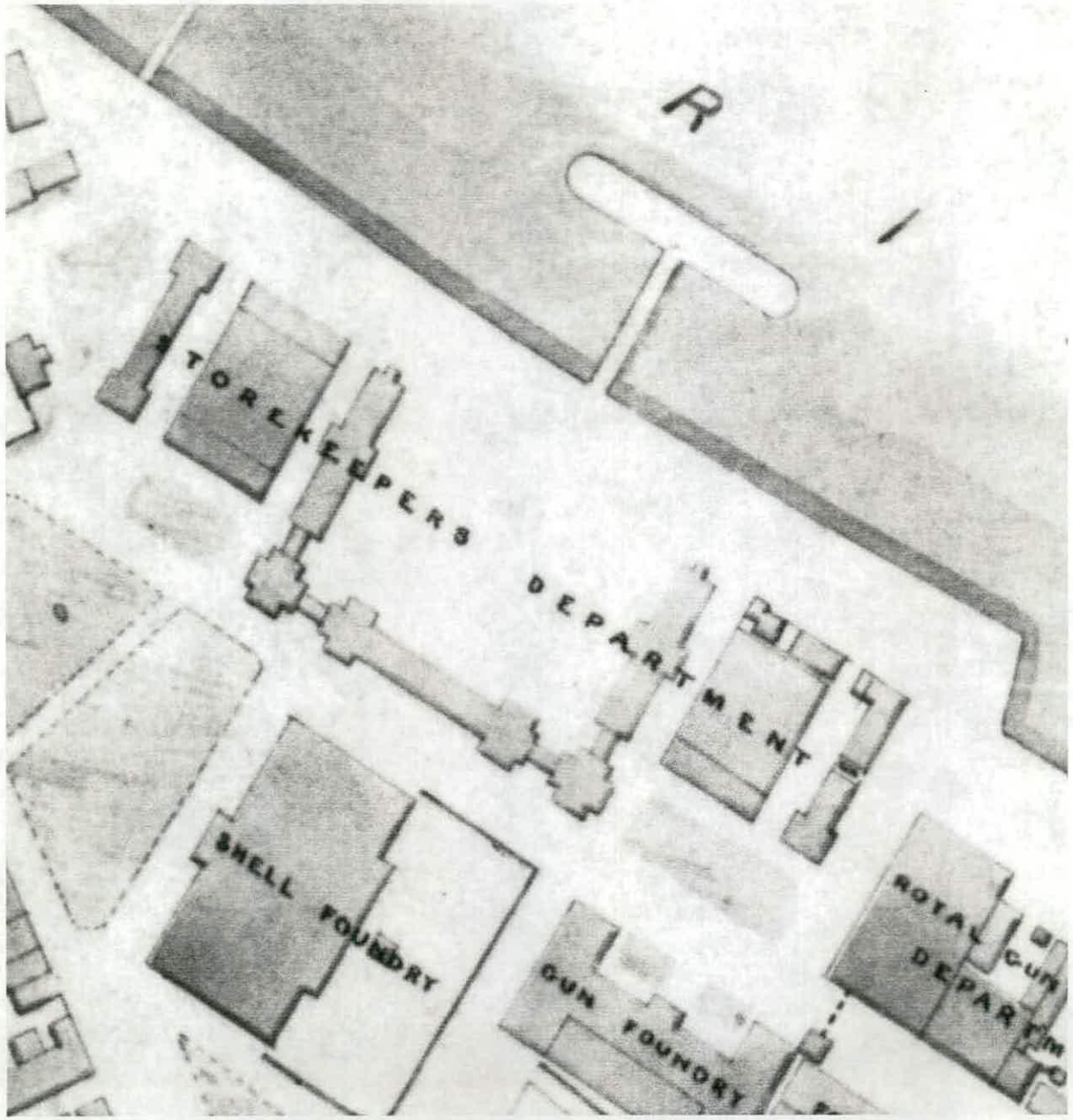
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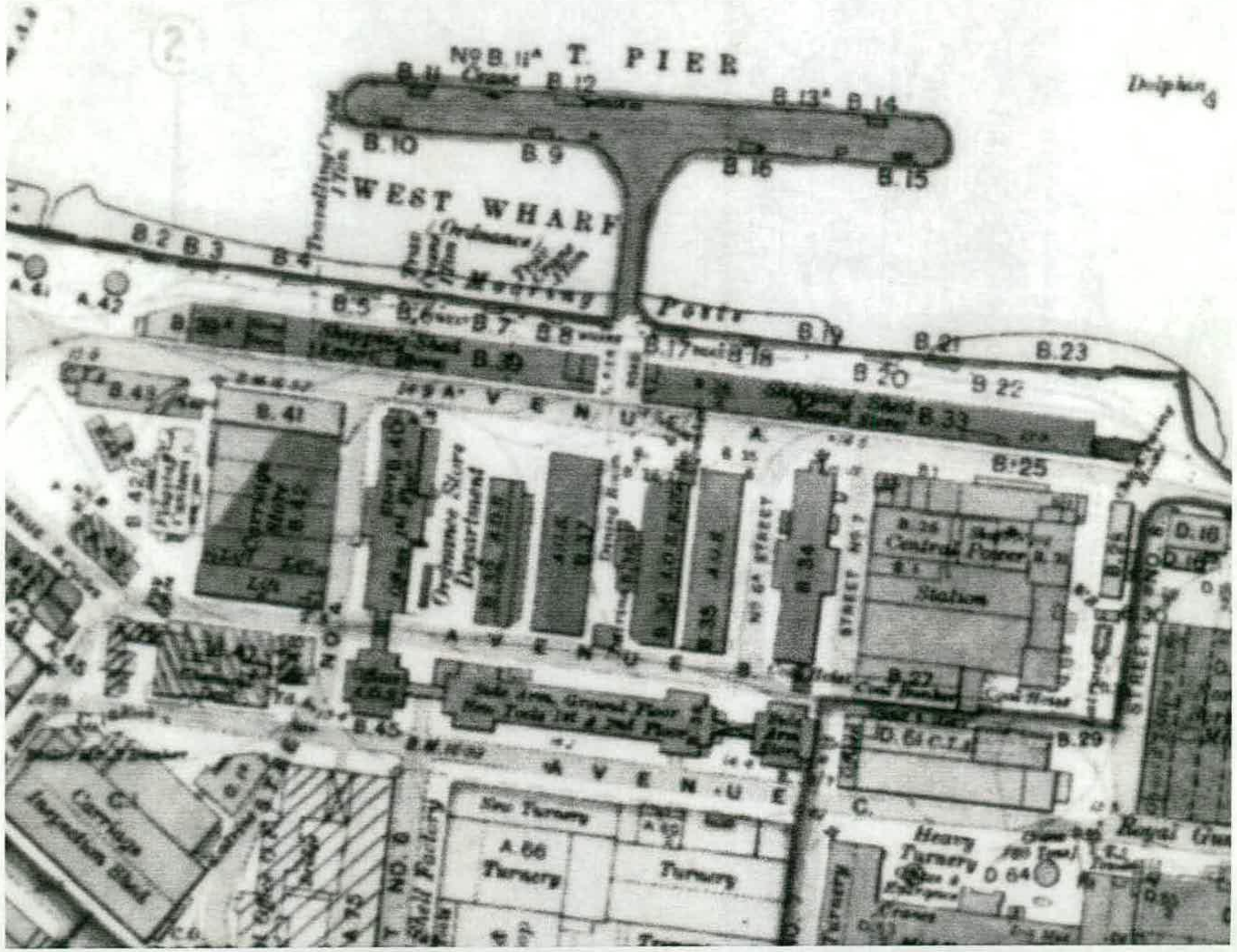
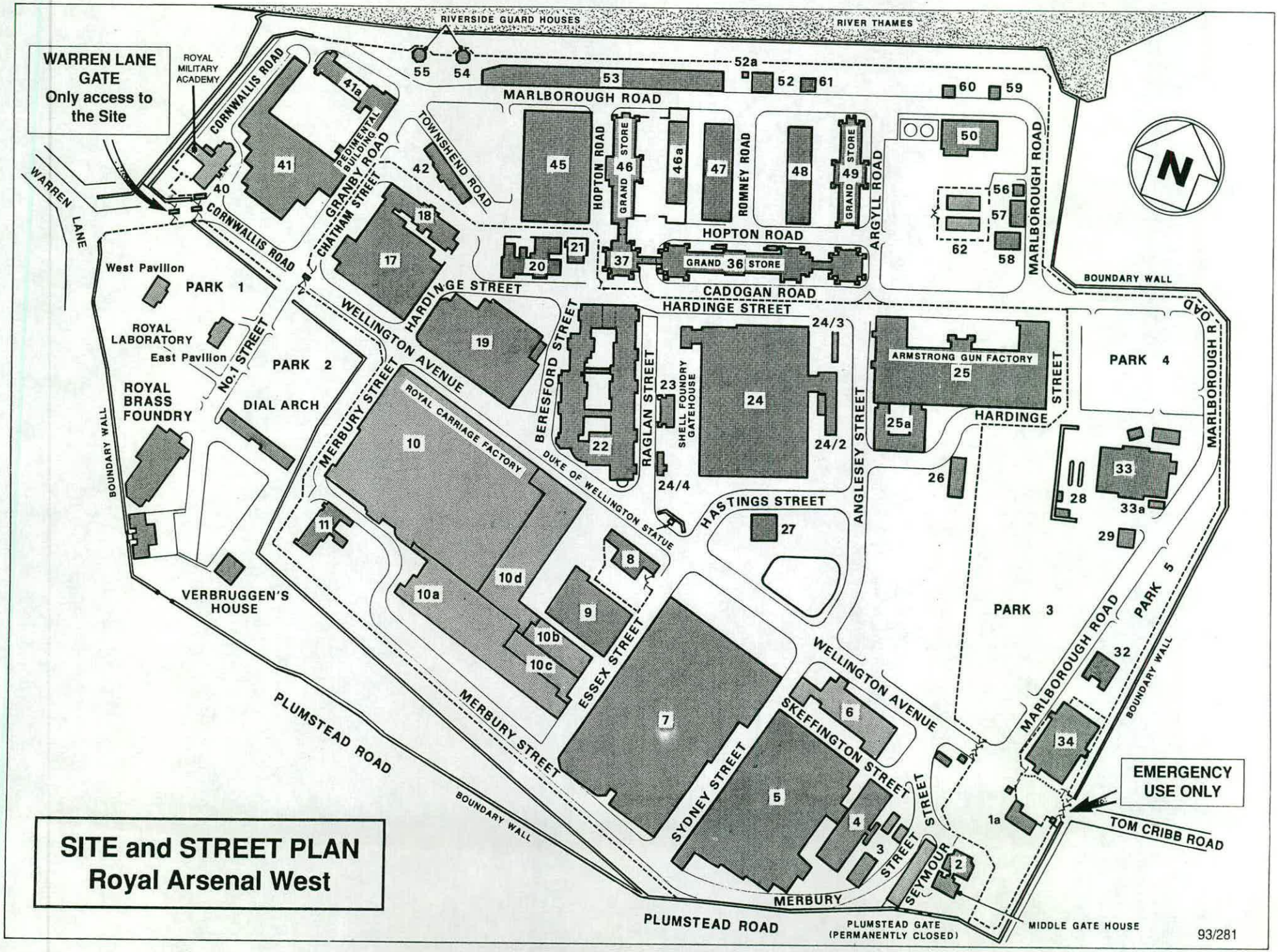

No B. 11A T. PIER
B. 11
Crane
B. 12
B. 13A
B. 14
Dolphin
B. 10
B. 9
B. 16
B. 15
WEST WHARF
(Ordnance)
B. 2 B. 3
B. 4
Mooring
Posts
A. 41
A. 42
B. 5
B. 6
B. 7
B. 8
B. 17
B. 18
B. 19
B. 20
B. 21
B. 22
B. 23
B. 39
B. 43
B. 41
A V E N U E
B. 33
B. 25
Ordnance Store Department
B. 34
Central Power
Station
B. 27
B. 45
B. 29
A V E N U E
C.
New Turnery
A. 66
Turnery
Turnery
Heavy Turnery
D. 64
D. 16
Royal Gun
Shell Factory
Carriage Inspection Shed


WARREN LANE GATE
Only access to the Site
ROYAL MILITARY ACADEMY
RIVERSIDE GUARD HOUSES
RIVER THAMES
CORNWALLIS ROAD
WARREN LANE
GRANBY ROAD
CHATHAM STREET
PEDIMENTAL BUILDING
TOWNSHEND ROAD
MARLBOROUGH ROAD
HOPTON ROAD
ROMNEY ROAD
ARGYLL ROAD
CADOGAN ROAD
HARDINGE STREET
BOUNDARY WALL
West Pavilion
PARK 1
ROYAL LABORATORY
East Pavilion
PARK 2
ROYAL BRASS FOUNDRY
DIAL ARCH
No.1 STREET
WELLINGTON AVENUE
MERBURY STREET
ROYAL CARRIAGE FACTORY
BERESFORD STREET
RAGLAN STREET
SHELL FOUNDRY GATEHOUSE
DUKE OF WELLINGTON STATUE
ARMSTRONG GUN FACTORY
ANGLESEY STREET
HASTINGS STREET
PARK 4
PARK 3
PARK 5
VERBRUGGEN'S HOUSE
ESSEX STREET
SYDNEY STREET
SKEFFINGTON STREET
SEYMOUR STREET
MERBURY
PLUMSTEAD ROAD
TOM CRIBB ROAD
EMERGENCY USE ONLY
PLUMSTEAD GATE (PERMANENTLY CLOSED)
MIDDLE GATE HOUSE
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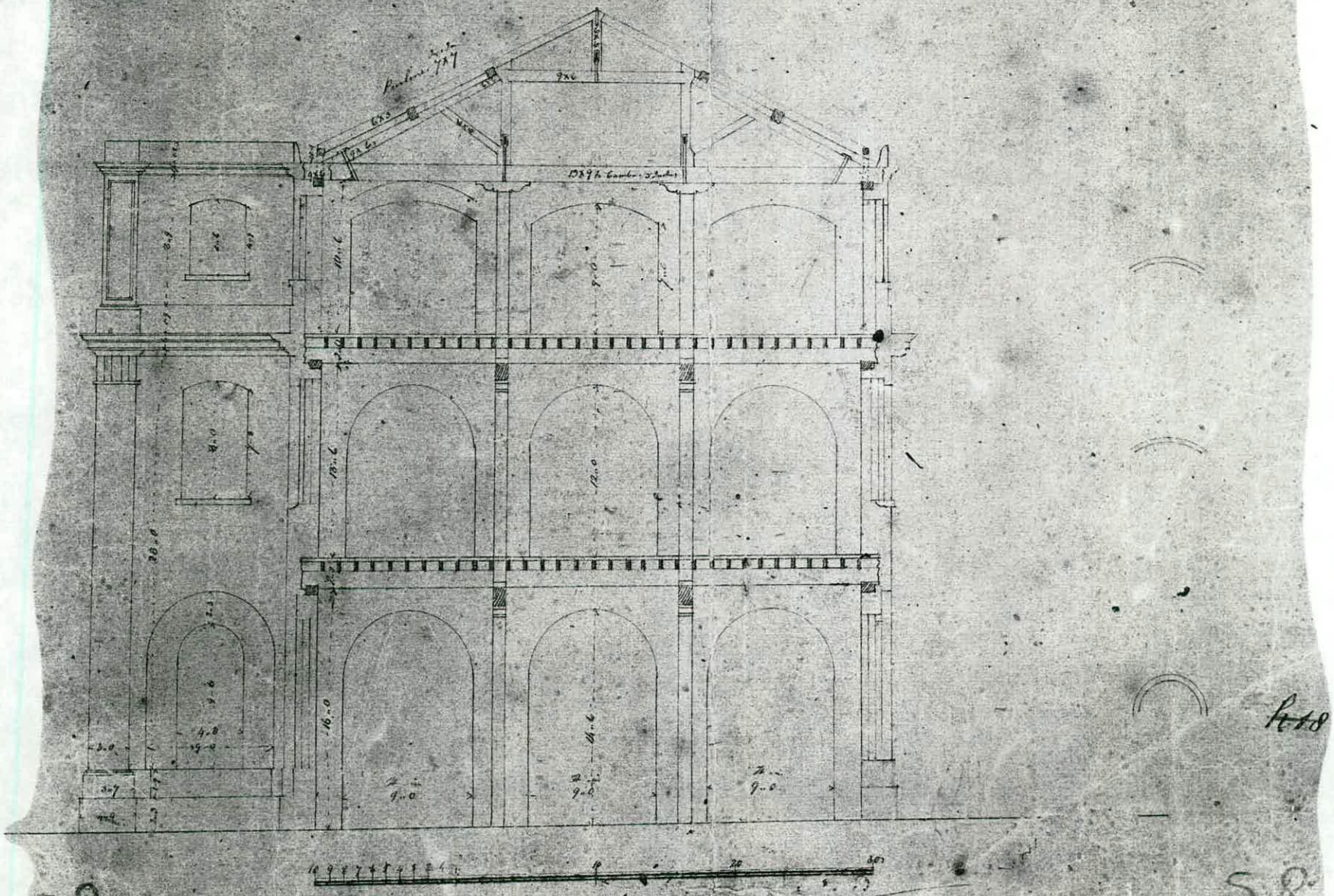
SITE and STREET PLAN
Royal Arsenal West
93/281

S 8

Section across the Center Storehouse Woolwich

S 8

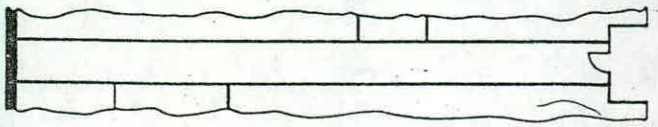
Section lengthways of one Bay



S 8

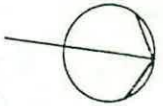
S 8

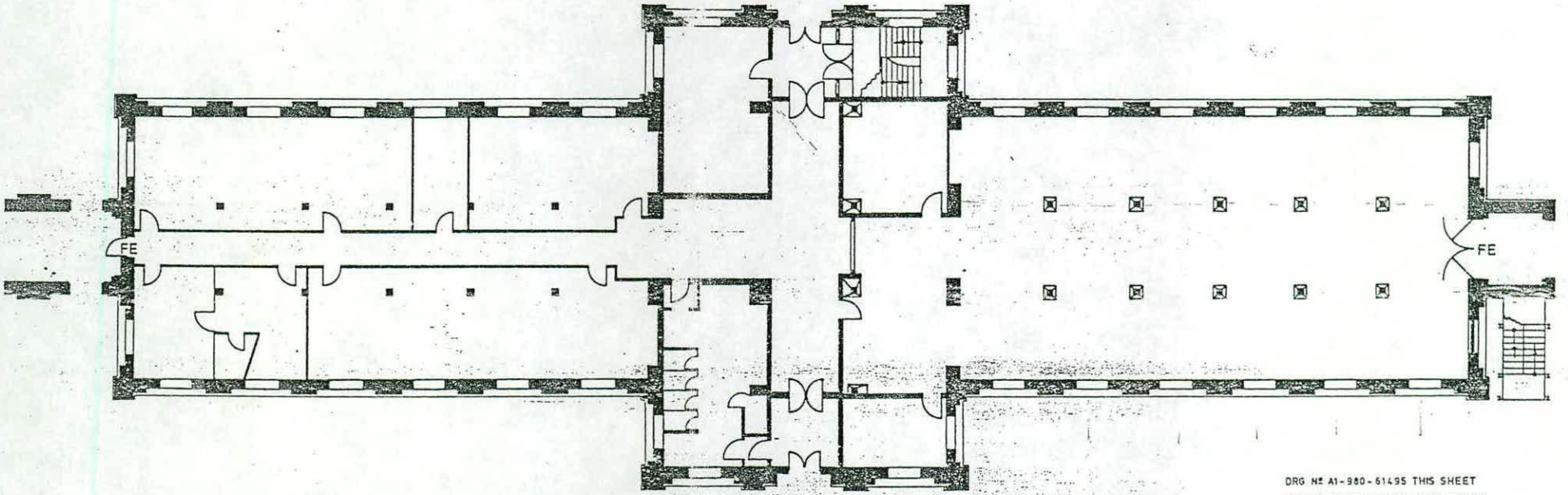
24,500 sq ft.



CRAWL PASSAGE

(above first floor corridor)





DRG Nº A1-980-61495 THIS SHEET

DRG Nº A1-980-61888 FIRST FLOOR

FE = FIRE EXIT

ROYAL ARSENAL WEST

BUILDING 46

GROUND FLOOR

0 5 10 15 20 25

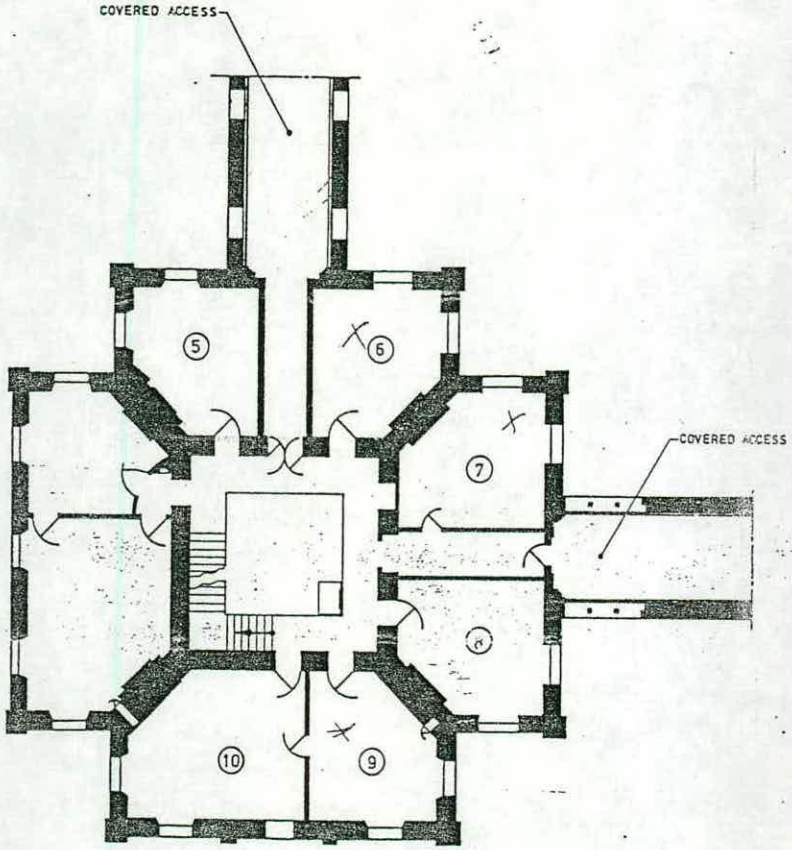
FEET

11000 sq ft (1022 m2)

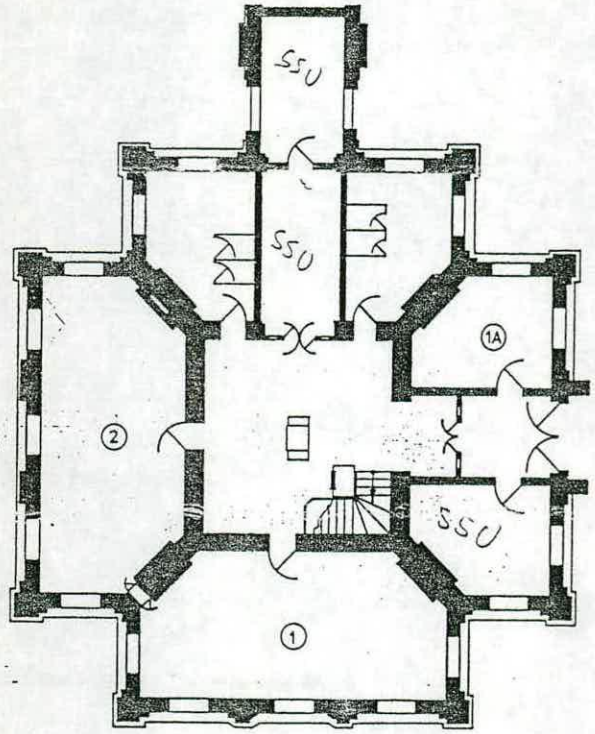
CHANGE	MOD Nº	ISS	DATE
CERTIFIED		1	18.8.88
DRAWING NUMBER			
A1-980-61495			

D.O. APP.	V.F.Nash
DRAWN	M.H. THORP
ORG. SCALE	1/8 IN = 1 FT

12,800 SQ FT.



FIRST FLOOR



GROUND FLOOR

DRG Nº A1-980-61486 THIS SHEET
DRG Nº A1-980-61854 SECOND FLOOR

D.O. APP.	K.F.W.
DRAWN	M. THORP
ORG. SCALE	1/8 IN = 1FT.

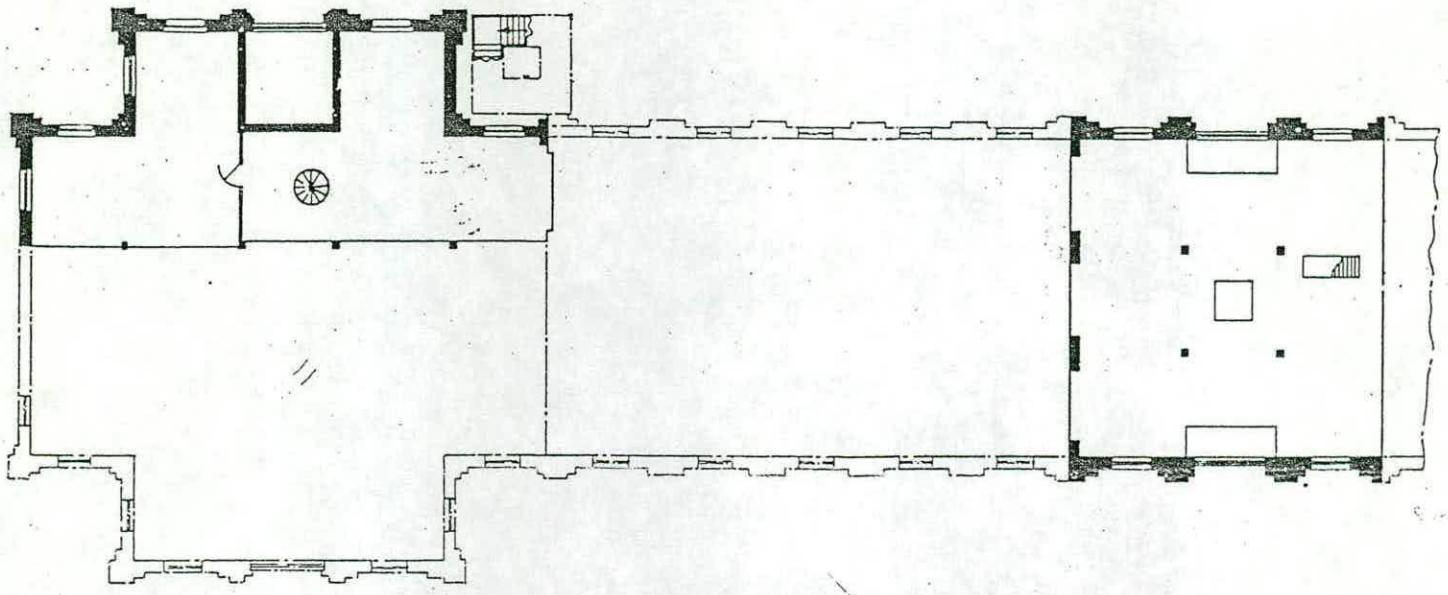
0 5 10 15 20
1234
FEET

ROYAL ARSENAL WEST
BUILDING 37

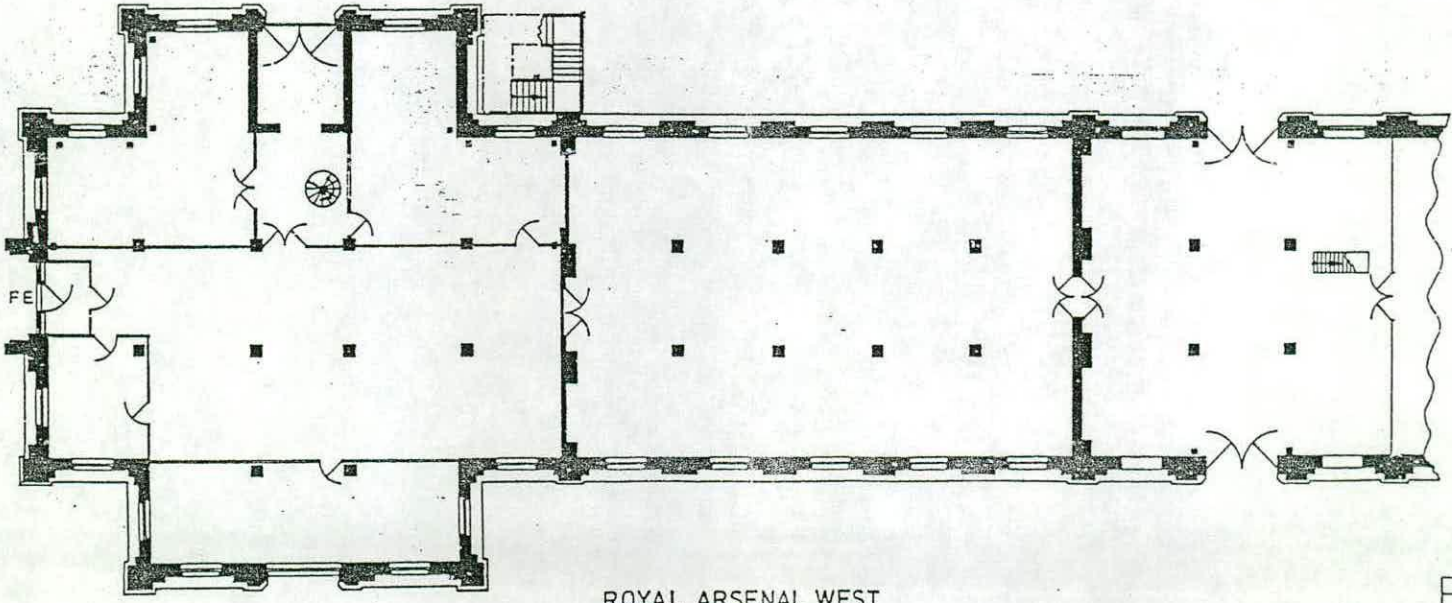
CHANGE	HOD Nº	ISS	DATE
CERTIFIED		1	6.7.88

DRAWING NUMBER A1-980-61486

78,300 SQ FT.



MEZZANINE FLOOR



FE = FIRE EXIT

. ORG. N° A1-980-61484 THIS SHEET
ORG N° A1-980-61485 FIRST & SECOND FLOORS

D.O. APP K.S.L.
DRAWN H. THORP
ORG. SCALE 1/8 IN = 1FT

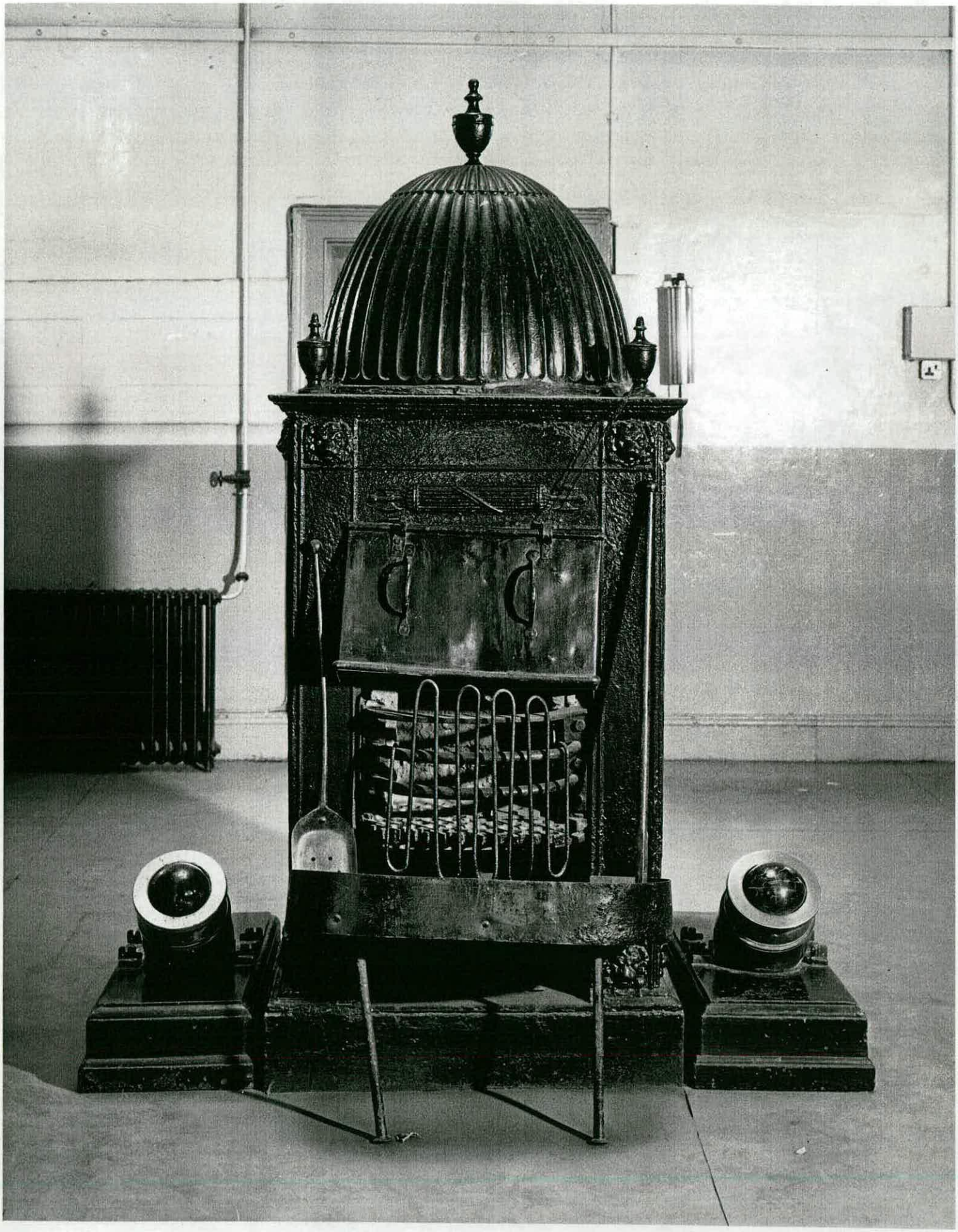
0 5 10 15 20
FEET

ROYAL ARSENAL WEST
BUILDING 36 (WEST)
GROUND FLOOR

REDRAWN AND UPDATED		2	23 3 90
CHANGE	MOD N°	ISS	DATE
CERTIFIED		1	

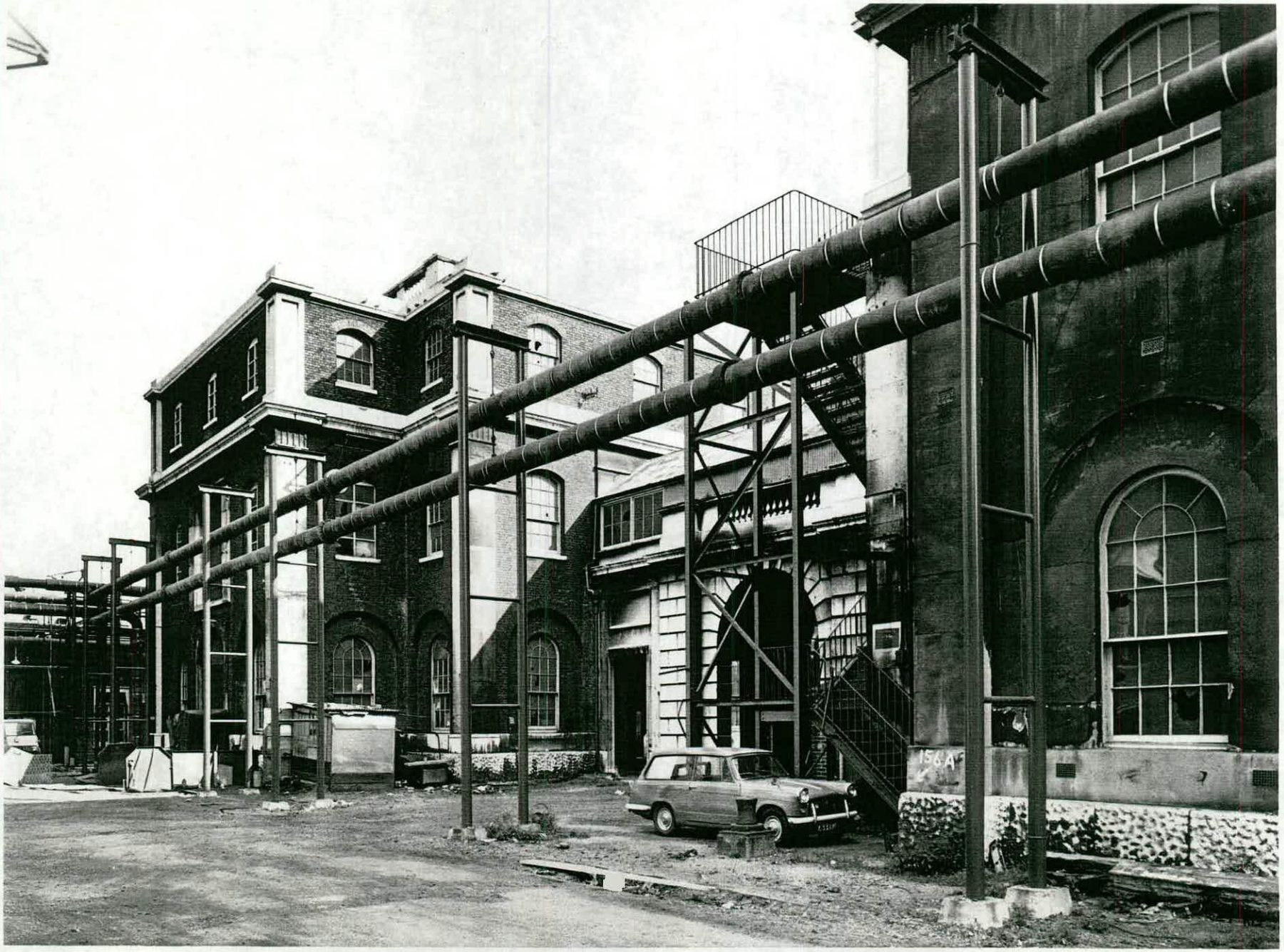
DRAWING NUMBER
A1-980-61484

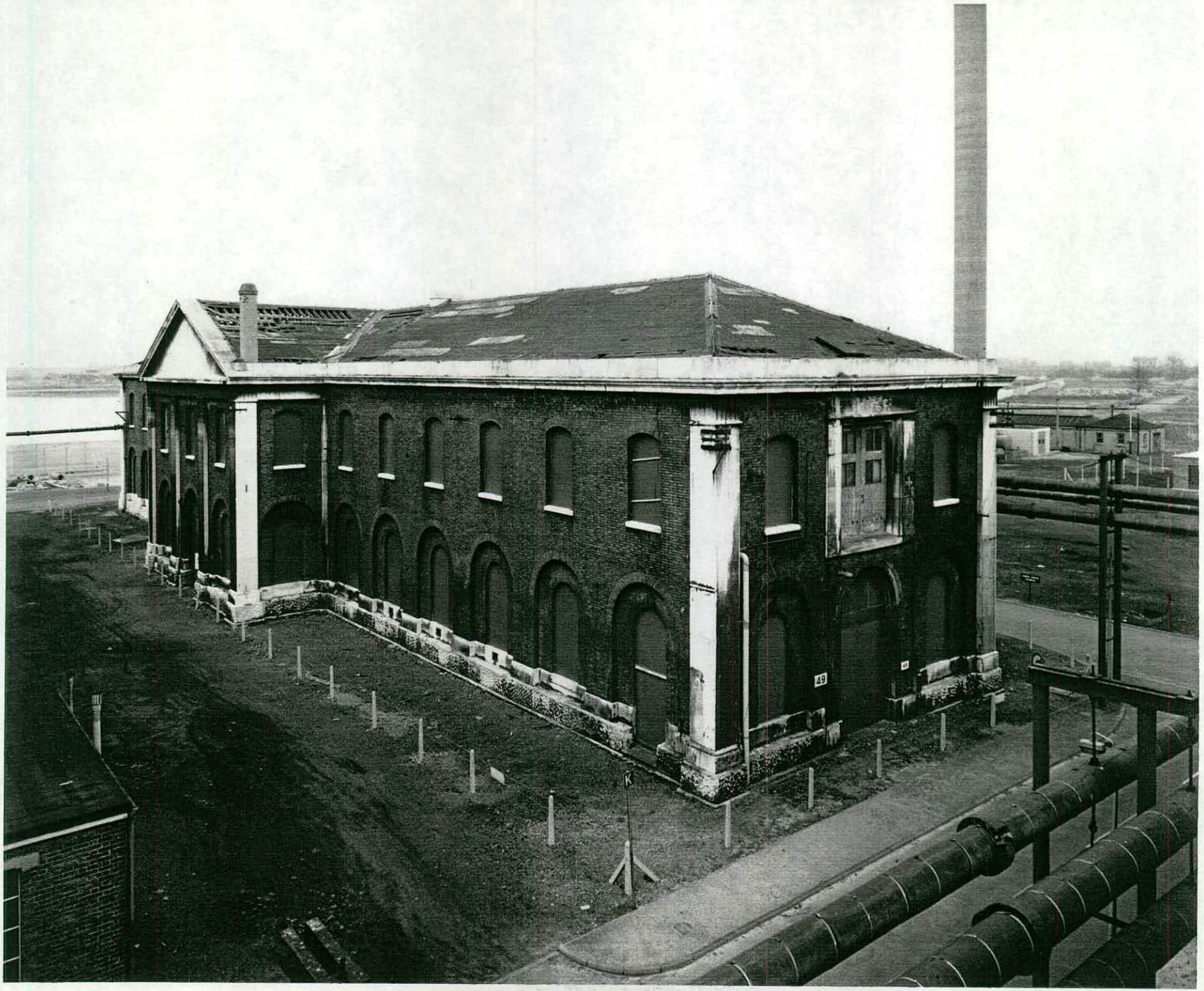

Fire alarm
EMERGENCY EXIT




THIS CAR PARK
IS RESERVED FOR
C.E.P.O. & A.C.A.
PERSONNEL ONLY
565 FKR


CAR PARK
Nº6
AVENUE B


156A


49

ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

London **NGR: TQ 440 793**

Greenwich **Building Index No: 92394**

The Royal Arsenal, Woolwich

Building 41/41A (New Laboratory Square)

Summary

This group of buildings forms an all but entirely closed quadrangle developed in several phases. It formed part of the Royal Laboratory and, in so much as it was an extension northwards from the original laboratory, it was designated New Laboratory Square. The long two-storey brick west range of 1805 is the earliest build. This was mirrored by the east range c1810 and the resulting yard was closed to the north at about the same time, in both cases with two-storey brick ranges. The east range was converted to be a temporary ammunition factory in 1854 in an emergency arising from the outbreak of the Crimean War coinciding with the rebuilding of the main laboratory quadrangle to the south. Steam engines were put up at either end of the range into which cast-iron columns were inserted. These columns survive with other evidence of drive shafting. Thereafter the quadrangle became a factory for boxes and barrels to pack ammunition. The east range was converted to use as a sawmill and cooperage. The west range was carpenters' shops. In 1878 the previously open south side of the yard was closed with a carpenters' workshop, initially a two-bay deep, north-lit, iron-framed structure. This was extended, first to the north c1890, then to the south in the early 20th century. The west range was rebuilt internally with a reinforced-concrete frame and the north range was raised a storey in mock-Tudor style and converted to office use.

Report

Building 41/41A comprises four ranges forming a quadrangle which is closed at all corners except the northwest. The south end of the east range and the south and east ranges are incorporated in Building 41. The north range, with the north end of the east range is identified as Building 41A. For the purposes of this report the entire building will be described as Building 41.

Building 41 was part of the Royal Laboratory - the ammunition manufacturing branch of the Arsenal. It is close to the western edge of the Arsenal site, near to the former Royal Military Academy of 1718-20 (later the Royal Laboratory Model Rooms) and to Building 17, which was the paper cartridge factory of 1855-6, and to the north of the original Royal Laboratory buildings of 1694-6. At one stage in the mid-nineteenth century the latter and the southern edge of Building 41 were very close indeed. The functions of the two buildings were probably very closely linked at this time. Building 41 was known as New Laboratory Square in the nineteenth century, reflecting its relationship to the earlier buildings to the south.

The earliest building is the east range which dates from 1805-6. This was followed by much of the east range by 1810, and the lower two storeys of the northern range were also built by 1810. These years were a period of growth and expansion in the Arsenal generally due to the Napoleonic Wars. The 1850s, the next significant period of development at the Arsenal, saw the refurbishment and refitting of several areas of these buildings, with the introduction of steam engines at the south end of the east range and as infill between the north and east ranges. Much of this work was prompted by the demands put upon the Arsenal by Britain's involvement in the Crimean War and by the need to produce ammunition for use with new types of weaponry.

The south range was the last side of the quadrangle to be built. The core of this building dates from 1878; it was extended northwards into the courtyard c1890 (when it began to envelope an earlier building, the desiccating house, which has since been demolished). Little new building has taken place during the twentieth century; much of the development of the buildings has taken the form of refurbishment and alterations to adapt to changing use, new processes and technology. The northern range was raised

a storey in the early twentieth century (probably around 1920). In addition to adding the second floor, the building was refurbished at this time. The last major discernible phase is the southwards extension of the south range, also in the early years of the twentieth century. It is also clear that some internal rebuilding and the installation of new machinery took place in the west range in the early/mid twentieth century.

The West Range

The west range is a two-storey stock-brick building of 15 bays by 3 bays. It is pedimented on the east side, and has a flat roof which is presumably a twentieth-century replacement of a hipped slate roof. This range is the earliest part of the complex. It appears on a map of 1806, and it may have been erected to replace the East Laboratory which was demolished in 1805 to make way for the Grand Store. By the 1820s it had been extended southwards (an extension later removed) and in 1853 it was in use for the finishing of paper and flannel cartridges. By 1864, after a comprehensive overhaul of the Royal Laboratory Department, it had been adapted to use as a carpenters' shop. Later in the nineteenth century a painters' shop and pattern room had been built abutting the south-western side of the building. This has been removed, but the west wall bears the scars of this. From within it is clear that the ground-floor window heads have all been rebuilt.

The presence of a pediment on the east side only, facing into what is now a courtyard, either suggests that the building originally addressed the rest of the Arsenal, to the east, or that a pediment on the west side may have been lost with the construction or demolition of the painters' shop and pattern room. The east wall exhibits patches of rebuilt brickwork. One, beneath the central window on the first floor and above a double door indicates the position of a door probably relating to a loophole bay. Other irregularities in the brickwork just below the string course suggest that there was once

lean-to roofing along this wall, possibly to protect stored materials or vehicles.

The interior of this building has been almost wholly rebuilt in the twentieth century, although it would seem that the crosswalls which divide off the two bays at each end are original. The first floor is now concrete, supported on concrete beams. There is a mid-twentieth century crane in the two south bays, indicating that this range was still in industrial use until quite recently. However, much of the first floor has been partitioned into offices.

The East Range

The east range is a very similar two-storey stock-brick building, originally of 15 bays by 3 bays. Unlike the west range it is pedimented on both west and east elevations. The building is divided into three sections of five bays, with a three-bay engine house of a later construction date to the north. The construction of the main fifteen bays followed soon after that of the west range; the east range appears on a map of 1810. The original timber floor construction, which survives at the north end of the range, is very sturdy; joists are 1 ft deep and only 1 ft apart. The original timber queen-post trusses with iron straps also survive, with fragmentary evidence of what may have been an internal hoist in the central bay.

In early 1854 the building was in use as a wood turnery. By 1864 it had become a sawmill on the ground floor and a cooperage on the first floor. It seems probable that this range was made an ammunition factory in 1854 in an emergency temporary conversion effected by Major-General Edward M Boxer, FRS, at a cost of £7,150. This was in response to the sudden demands generated by the Crimean War, arising whilst a new Royal Laboratory factory was being built to the south of New Laboratory Square.

Hogg describes a temporary factory "with two steam engines and many hundreds of feet of shafting, machines, tools, etc. producing a large increase in ammunition". Much about the east range fits it to this description. Steam engine and boiler houses were added at either end of the range after 1853 and before 1858. The northern one of these remains, partially rebuilt, but the southern one has been demolished. The ground floor has hollow cylindrical cast-iron columns (27cm diameter) designed to carry drive shafting and therefore an insertion contemporary with the engine houses. They are cast with a T-shaped bolting face for the bracket which supported the drive shafting. I-section cast-iron beams, which run N-S on the ground floor have parabolic lower flanges with central flat square depressions with 4 bolt holes in the soffit, presumably for attaching brackets to the drive shafting. There were similar columns for the length of the first floor. Some of these have been removed, as evidenced by scars in the tie beams.

These features were all probably installed in the 1854 refit organised by Major-General Boxer. The floor of the southern five bays is 75cm lower than the ground floor of the rest of the east range. The first floor in this area was remade in the late nineteenth century with metal girders and joists and concrete plate flooring. The former engine and boiler house to the north has an inserted floor on what appear to be late-nineteenth-century cast-iron columns. The original north end wall of the east range has been opened up, probably after 1854, and, on the ground floor, there is a complex arrangement of girders and octagon-section columns, suggesting subsequent reinforcement.

Part of the first floor at the south end was converted into a firing range in the mid/late twentieth century and remained in use as such until the area was vacated in 1994. A circular hole, formed in the brickwork on the east wall has been bricked up. It breaches

the floor line. Possibly the circular hole in the wall was for despatching the completed barrels out of the first floor cooperage via a chute. Following the Crimean War conversion the whole of Building 41 seems to have been adapted to use as a box and barrel making facility for the packing of ammunition made in the Royal Laboratory factory nearby to the south.

The North Range

The three-storey eastern building of the north range is attached to the engine house at the north end of the east range. Whilst the main north block dates from c1810, this building is not present on a map of 1858, but had been built by 1864 when it was shown as a boiler house. It seems to relate to the boiler house created at the north end of the east range during Major-General Boxer's conversion of the building in 1854. It may have been built to supplement its capacity when the east range came to be used as a sawmill. It has a composite iron roof of mid-nineteenth century character, but no other obviously original internal fabric. A w.c. block attached to this block is of an age with the refurbishment of the main block of the north range (early twentieth century).

The main (and earliest) block of the north range has three storeys. The two lower storeys are roughly contemporary with the east range, that is c1810. This block is described on the map of 1864 as a store, and in 1888 as a Military Instruction Room. The ground and first floor elevations are stock brick. The ground floor has large arched windows, supplying the relatively shallow rooms with good light from both north and south. The north elevation has slightly larger ground floor windows (except at each end) than the south, and an entrance in its centre bay. The proportions and fenestration of the ground and first floors are similar to those of the west and east ranges. The upper storey is rendered and timbered in an ordered mock-Tudor domestic style and is a c1920

addition. The most puzzling feature of this block is a thick spine wall (74cm at ground floor level, 73cm at first floor level) which suggests that, from the outset, the building was functionally split down the middle. Possibly the thickness of the wall was required to separate incompatible stores, for protection from fire or explosion, or perhaps for noise or security reasons. There are three arched openings in this wall which are probably original.

There is no nineteenth-century interior joinery. Possibly the interior was not embellished because it was a utilitarian space, or perhaps it was lost during the evidently comprehensive early-twentieth-century refurbishment of the building for office use, at the same time as the third storey was added. This storey may have been office accommodation as the rooms are all small, and each has a fireplace.

A map of 1853/4 shows the main block of the north range as a paper cartridge factory on wholly different lines. This map was drawn up for a committee charged with improving the facilities of the Royal Laboratory Department. It seems that some of the proposals depicted were not carried out, presumably because of the emergency conversion of the east range in 1854. A paper cartridge factory was built in 1855-6, on another site to the east of Building 41. This building survives as Building 17.

The South Range

The south range is a cast-iron framed structure, a large open single-storey north-lit workshop, the earliest part of which dates from 1878. The ironwork is closely based on that used in 1854 for the building of the Royal Laboratory Factory to the south, though it is cast with the date 1878. The walls are stock brick and corrugated iron with large windows. It consists of 6 bays of varying lengths roofed with saw-toothed profiled north

lights. Map evidence indicates that only two bays, that bearing the date and that to its north, are from 1878. Two further bays to the north were added c1890, and may once have been extended further into the yard. The two southern-most bays were built in the early twentieth century, before 1931. The windows and roof covering of these two bays have been replaced since the late 1960s. The nineteenth-century roof trusses are constructed of T-section cast-iron struts and principals and slender wrought-iron circular-section struts and rods. The roofs are hipped at their west ends to allow light penetration into the west and east ranges, which pre-date the south range. The hollow-cylindrical columns are of 18cm diameter. Housing for line shafting is clearly visible along the cast-iron frame with housings for pendant brackets in the iron beams.

Evidence of a former desiccating house appears at the north end of the south range. This desiccating house was presumably used for seasoning timber before it was used by the carpenters and coopers. In 1888 this block was described as carpenters' shops, having previously been described as the drying house. Segmental scars on the exterior north of the south range wall are of canopies which flanked this building. A photograph of 1969 shows them then to have been car-ports. These may have been storage areas at one time.

The east wall retains part of the former exterior wall of the south engine house of 1854, which has otherwise been demolished. The floor of this range is at a higher level than those ranges on either side. Possibly it has been raised to allow drainage underfoot.

References

Maps - PRO, WORK 43/492(1810), 499(1858), 501(1864), 506(1888), 515(1931)

Brigadier O.F.G. Hogg, The Royal Arsenal: its Background, Origin and Subsequent History, 1963, pp. 551, 703, 782

PRO, WORK 43/1302 (drawing of the Royal Laboratory Improvements of 1853/4)

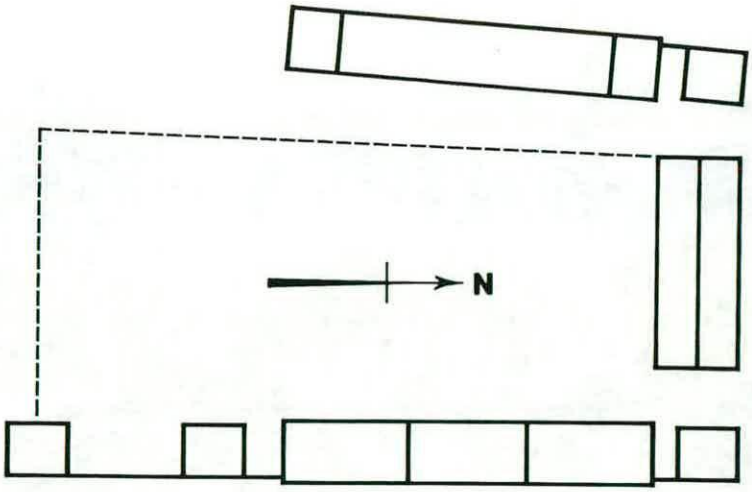
Quarterly Review, Jan.-April 1858, pp. 256-7.

Recorded by Charlotte Bradbeer and Derek Kendall, June 1994

Report by Charlotte Bradbeer, October 1994

LIST OF ILLUSTRATIONS

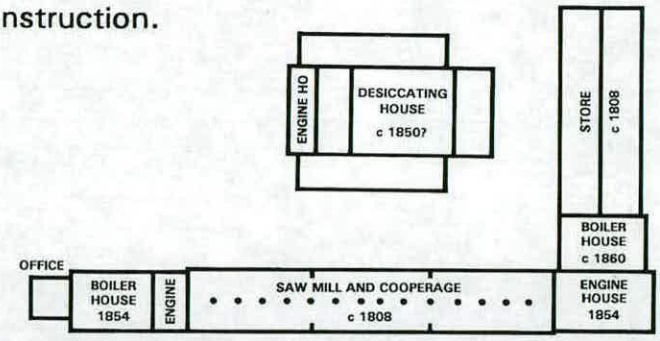
1810



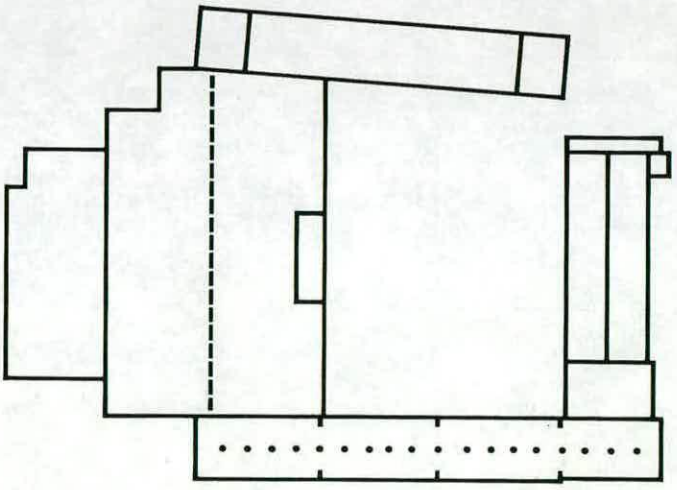
1864

Uses refer to 1864.

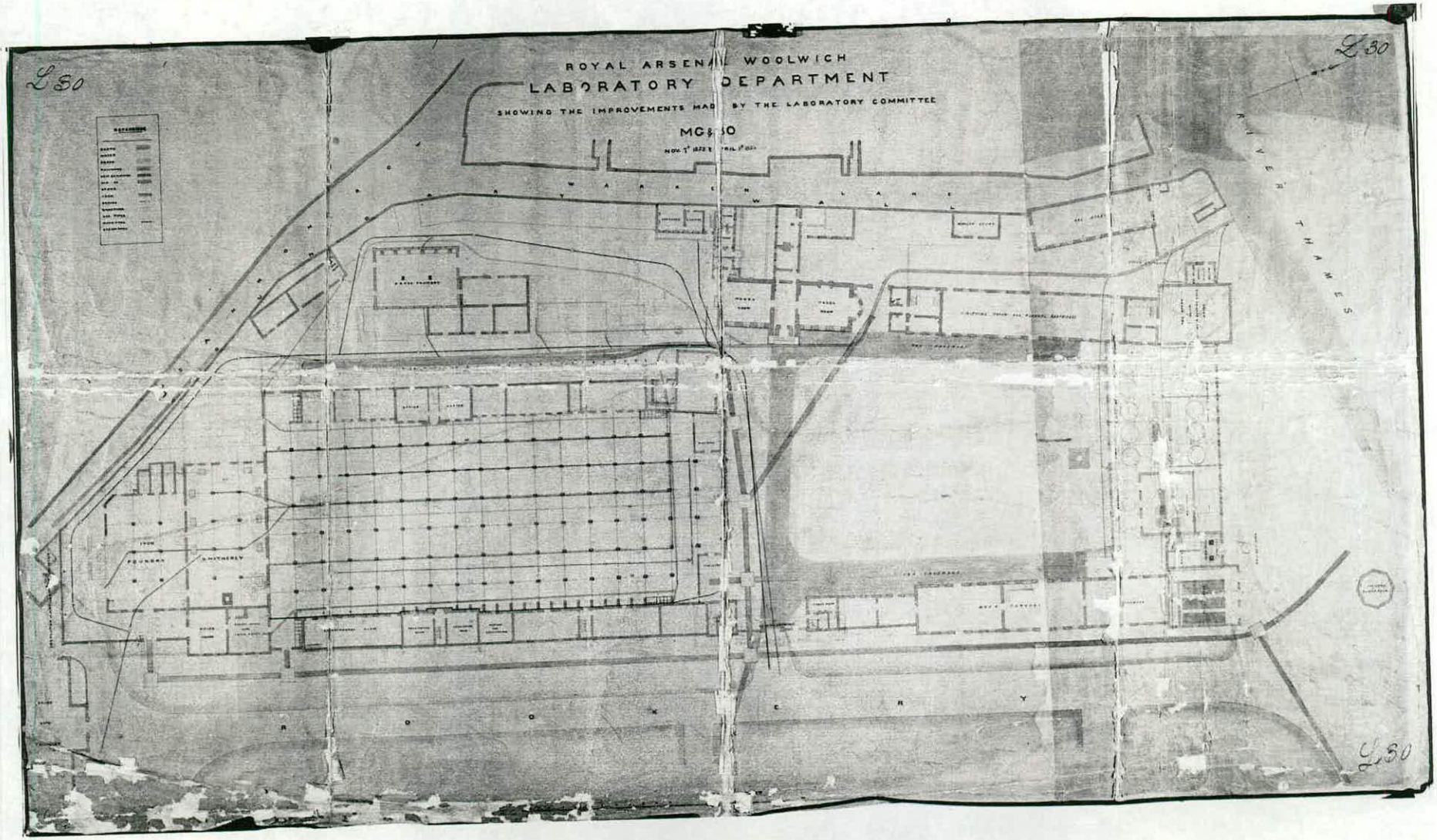
Dates refer to original construction.

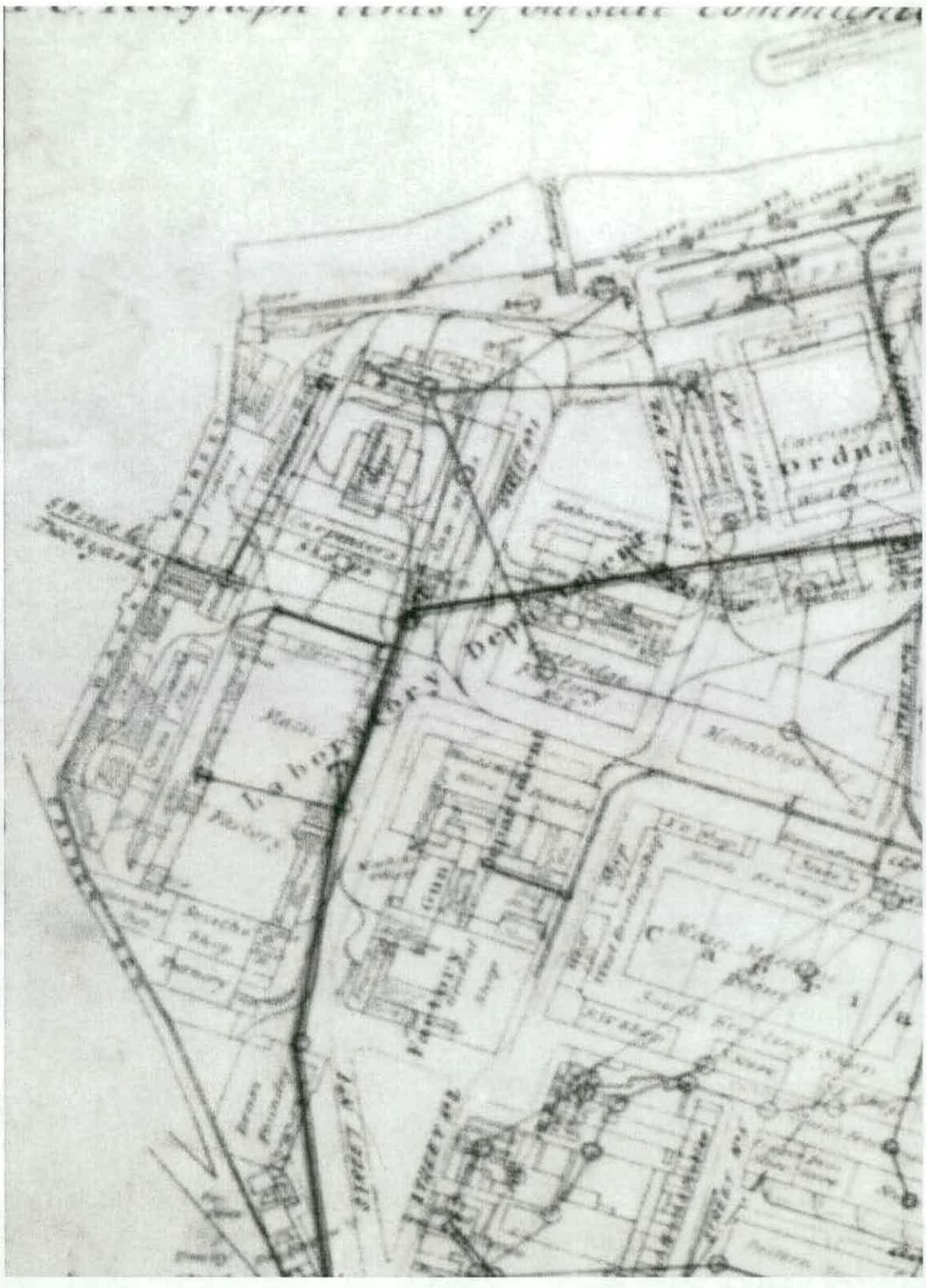


1994

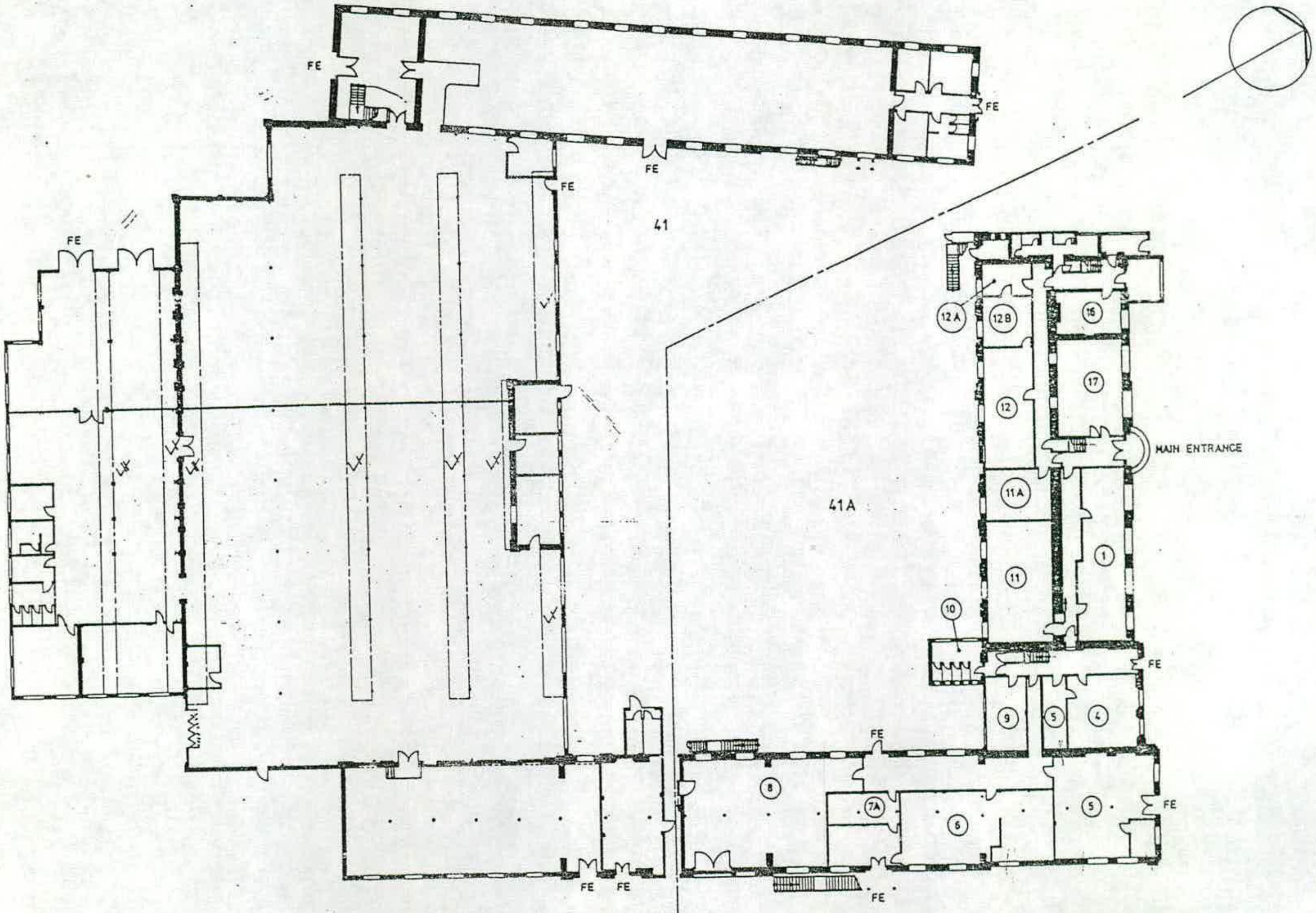


Block plans of Building 41 & 41A showing development from 1810 to 1994.


ROYAL ARSENAL WOOLWICH
LABORATORY DEPARTMENT
SHOWING THE IMPROVEMENTS MADE BY THE LABORATORY COMMITTEE
MG&SO
RIVER THAMES



35,000 SQ FT.



GROUND FLOOR

ROYAL ARSENAL WEST
BUILDING 41 & 41A

DRAWING NUMBER A1-980-61488 – THIS SHEET
DRAWING NUMBER A1-980-61865 – FIRST / SECOND FLOOR
FE – FIRE EXIT
NORTH LIGHTS (OVER)
SOUTH LIGHTS (OVER)

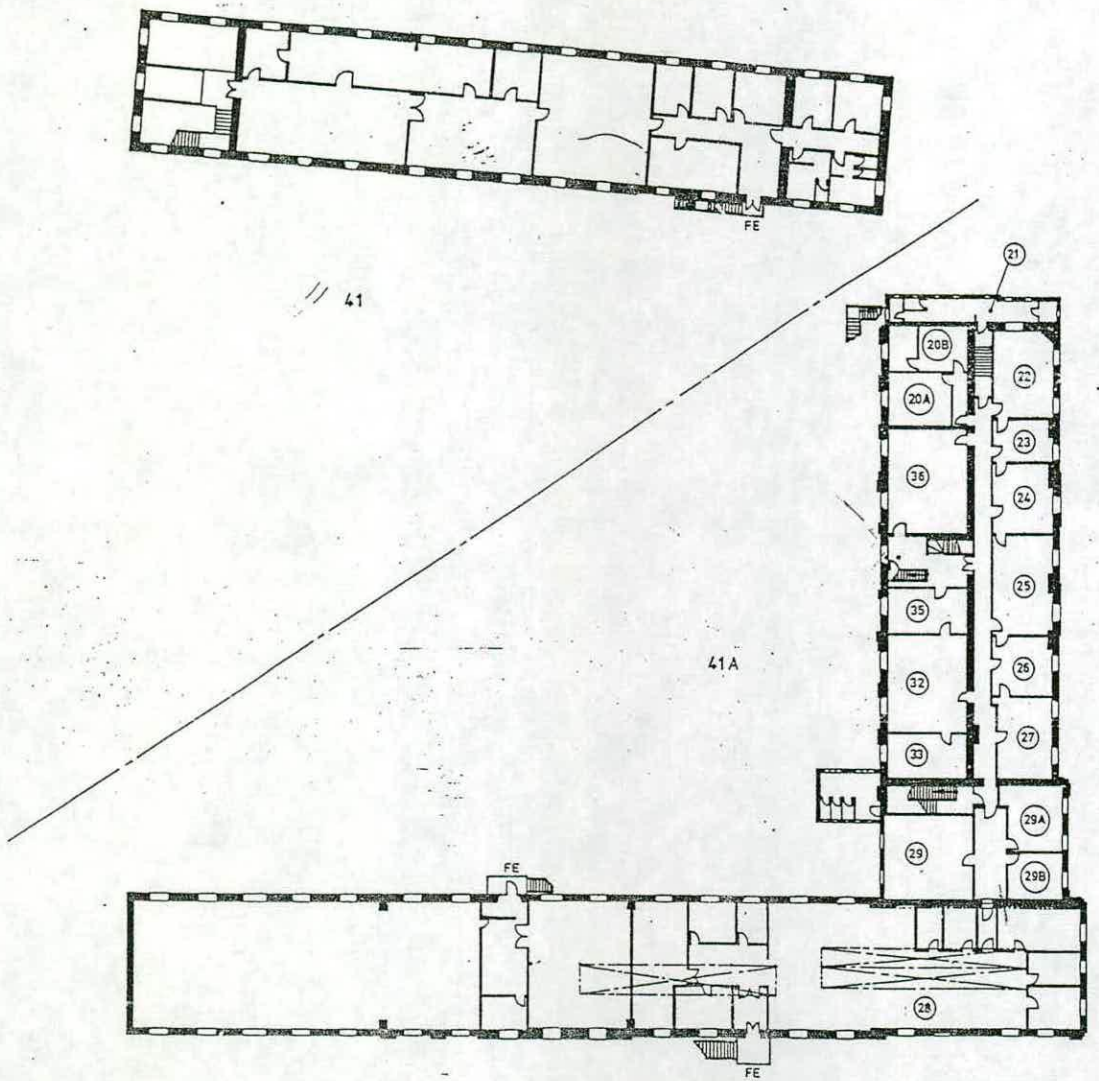
CHANGE	MOD. NO.	ISS	DATE
CERTIFIED		1	22-7-[illegible]

DRAWING NUMBER A1-980-61488

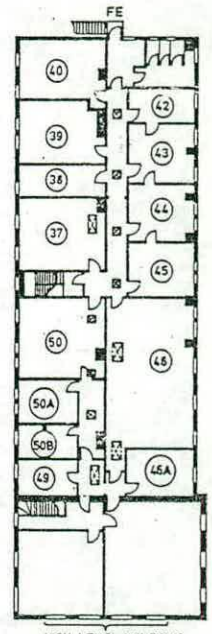
D.O. APP. K.F.New.
DRAWN J.BAKER
ORIG. SCALE

FEET
0 10 20 30 40 50
2 4 6 8

NOTE:-
THIS DRAWING REPRESENTS THE GENERAL LAYOUT OF THE BUILDINGS / ROOMS / FLOOR SPACE WHEN ACCURATE ANALYSIS OF AVAILABLE SPACE IS REQUIRED MEASUREMENTS SHOULD BE CHECKED



FIRST FLOOR 41/41A



SECOND FLOOR 41A

DRAWING NUMBER A1-980-61486 – GROUND FLOOR
DRAWING NUMBER A1-980-61885 – THIS SHEET
FE - FIRE EXIT
ROOF LIGHTS

ROYAL ARSENAL WEST
BUILDING 41 & 41A

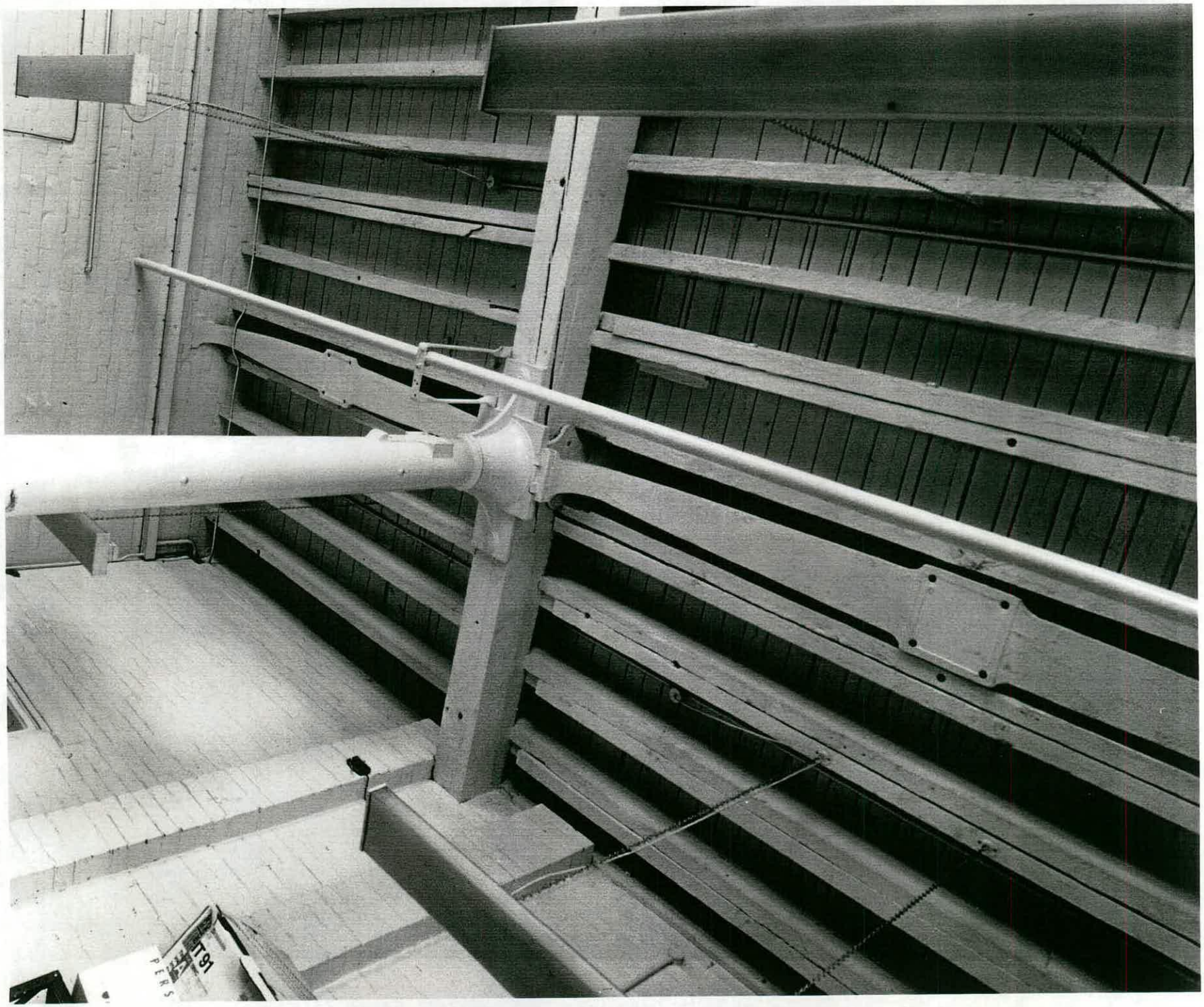
D.O. APP	VE
DRAWN	J.BAKER
ORIG. SCALE	1/16 IN. = 1 FT.

FEET
0 10 20 30 40 50
2 4 6 8

NOTE:-
THIS DRAWING REPRESENTS THE GENERAL LAYOUT OF THE BUILDINGS/ROOMS/FLOOR SPACE WHEN ACCURATE ANALYSIS OF AVAILABLE SPACE IS REQUIRED MEASUREMENTS SHOULD BE CHECKED

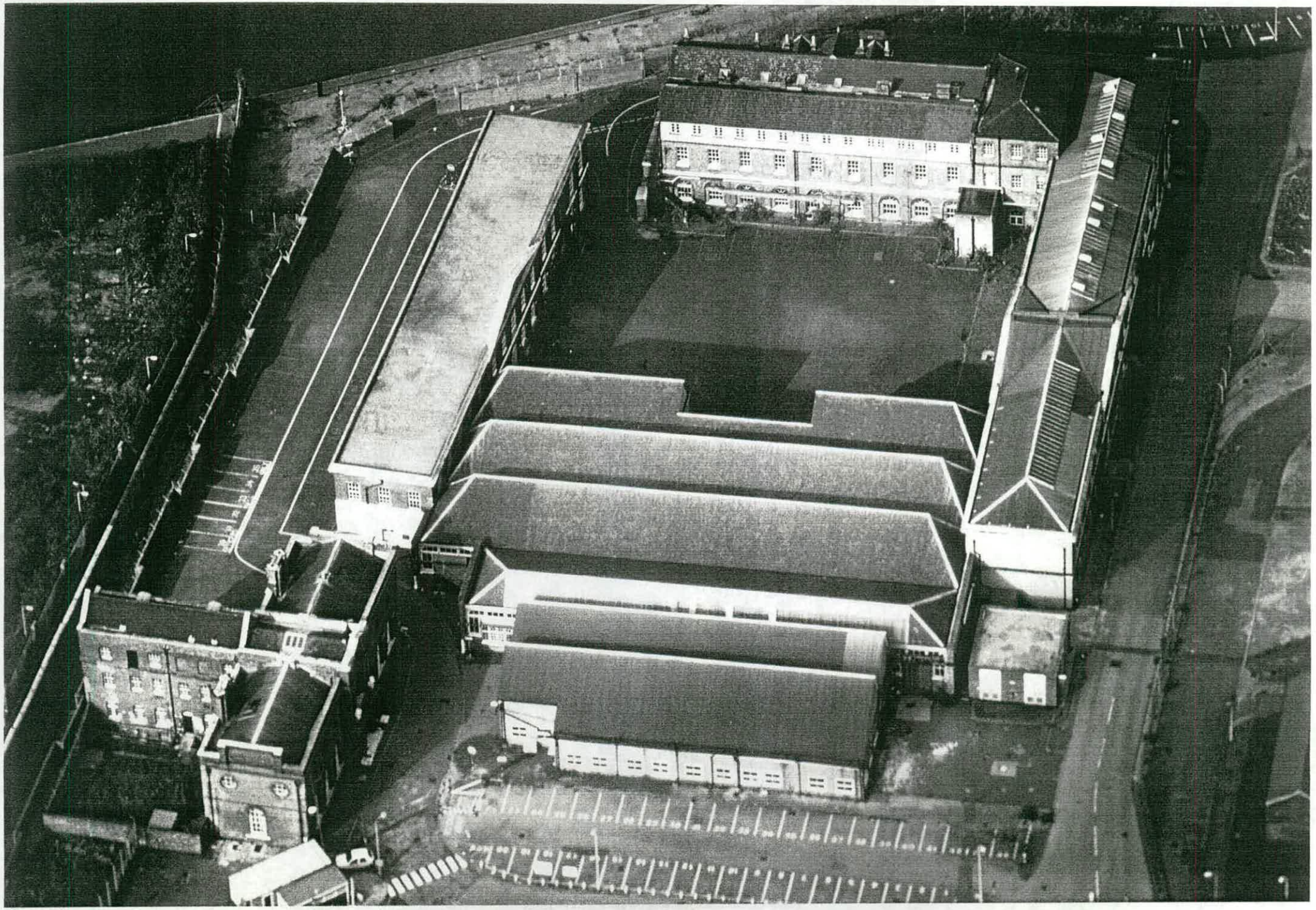
CHANGE	MOD. NO.	ISS.	DATE
CERTIFIED		1	22-7-88
DRAWING NUMBER	A1-980-61885		


41A
41




MT904
MT93
MTF94-1


FIRE EXIT



ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

London **NGR: TQ 440 793**

Greenwich **Buildings Index No: 92394**

The Royal Arsenal, Woolwich

Building 17 (former Paper Cartridge Factory)

Summary

Building 17 was erected in 1855-6 as a Paper Cartridge Factory to designs by Lt. Col. R. S. Beatson, RE. It has a two-storey cast-iron frame within brick walls. Parts of the internal frame have been removed, but it survives as a good example of robust mid-19th-century iron construction. Details in the fabric of the building knit together with a detailed account from 1858 of the processes in the building to allow an exceptionally good understanding of the original functional layout of a mid-19th-century factory that combined advanced machine technology with mass child labour.

Report

Introduction and Background

Building 17 is a two-storey rectangular block, iron-framed within brick walls. It was erected in 1855-6 as a Paper Cartridge Factory. The lower storey was the machine shop, where paper cartridge bags and percussion caps were manufactured. The upper storey was a workshop for the manual assembly of other paper cartridge bags. The building was converted to metal cartridge production c1884 (see below). By 1932 it was in use as an RAF Bomb Shop.[1] Latterly it has served as defence research laboratories. It has been extended to the rear and much altered, with most of the floor to the upper storey removed.

The Paper Factory was put up and managed as a part of the Arsenal's Royal Laboratory Department which controlled the manufacture of ammunition. Its construction formed part of a vigorous campaign of improvement to what had become an outmoded and inadequate establishment. In 1852 the Board of Ordnance set up a committee to make the Royal Laboratory more efficient (Major-Genl Cater; Col. Wilson, RA; Col. Tulloh, RA; Col. Pickering, RA; Capt. Warlow, RA; Capt. Collinson, RE; John Anderson, Inspector of Machinery). This committee introduced steam-powered manufacturing to the production of small arms at Woolwich on a large scale (see also Buildings 23 (the Shot and Shell Foundry) and 41/41A). A process for the machine manufacture of small-arms bag cartridges was devised and probably destined for the north end of New Laboratory Square (Building 41). The outbreak of the Crimean War in 1854 seems to have disrupted these plans and in 1855 the decision was taken to erect a separate building for this purpose.[2] Drawings for the building were signed by Lt. Col. Roger Steward Beatson over the period September 1855 to May 1856.[3] Benjamin Hick and Son were contracted to supply machinery.[4] The building was in use by 1857[5] on a site to the east of earlier Royal Laboratory buildings (41/41A) and north of the Dial Square Gun Factory complex. To its north an office building for the Royal Laboratory Department (Building 18) had been erected as part of the same development.

In July 1855 Beatson (1812-96), then a Captain, was appointed Superintending Royal Engineer to the Ordnance Manufacturing Departments, succeeding Capt. Collinson, RE.[6] Earlier he had been responsible for innovative uses of structural iron at Portsmouth naval dockyard, a free-standing two-tier cast-iron water tower of 1843, and trussed cast-iron floor beams in Boat House No. 6 of 1845-8.[7] The Paper Factory reflects some of the features and characteristics of these buildings, but it can not be said to be comparably innovative in its

structure. The contractors for the ironwork are not known. Benjamin Hick and Son, who were supplying the machinery, were supplying iron elsewhere at Woolwich Arsenal in this period, as were Henry Grissell (who had worked with Beatson in Portsmouth) and Fox, Henderson and Company.

The building was converted to the making of metal cartridge cases c1884 when expenditure on accommodation for the manufacture of cartridge cases for rifles and machine guns was approved.[8] In 1881 it was still a 'cap and paper factory',[9] but an 1891 account of it as the 'cartridge case factory' mentions only metal case making[10] and a map of 1888 shows an 'iron shop' and an 'annealing shop' to the north of what was then labelled Cartridge Factory No. 1.[11] Rolling mills had been introduced and the upper floor equipped with machinery for the manufacture of cartridge cases for '6-in., 4.7, and Hodgkiss quick-firing guns'.[12]

Description

The building comprises a large rectangular block (about 53m by 26m) with a cluster of ancillary structures covering a comparable area to the north.

The main block has a prominent 19-bay front elevation to the south facing onto the east-west avenue (latterly Wellington Avenue) that divided the Royal Laboratory Department from the Royal Carriage Department. The main walling is of stock brick with segmental-headed openings, all the windows being 20th-century metal-frame replacements with sills renewed in concrete. Corner pilasters and a wider central bay are in red brick, the latter projecting slightly for the principal entrance. This entrance and the window above are wide openings

with key-blocked stone surrounds. There are replacement double doors under an original fanlight. Secondary entrances in the outer bays are not as drawn in 1856.[13] That to the east is central to the nine east bays, whereas it was drawn to be west of centre. Despite this it appears to be an early if not original opening to judge from the plinth and the joinery of the door frame; the door has been replaced. To the west there is a broader opening with double doors. This is clearly secondary with repair evident in the surrounding brick. The door position may be original, yet again it does not correspond with the presentation drawings. The main block has twin hipped roofs running east-west, recovered with skylights. Drawings indicate that there were no skylights originally and that there were louvred vents along the ridges.[14]

Other elevations are similar. To the east the main block is nine bays, the centre bay breaking forward with an entrance that has been made a window.[15] An original two-storey ancillary block extends northwards from the east end of the north side of the building. On the lower level this was a rag store.[16] Its five-bay east elevation echoes the main block architecturally, as does the three-bay north return. On both these elevations there are central entrances; here stone sills survive. The roof of the rag store block has been rebuilt in recent times with a steeply-pitched hip screening a modern boiler house on a concrete flat.

The main nine-bay west elevation has a projecting central bay. Here, however, there was no entrance originally and many openings were blind as the north-west corner of the main block was the site of the engine house.[17] A large opening with a concrete lintel was inserted near the northwest corner, and subsequently blocked. Onto this side a single-storey, five-bay block with a broad central entrance was added c1900. This was a second engine house, latterly

converted to use as toilets.[18]

The north wall of the main block originally opened onto an enclosed yard, but it is now largely concealed within later additions. Original ancillary structures at either end left this an 11-bay elevation on the ground floor, asymmetrical around a projecting entrance at the centre of the block. A door has been inserted towards the west and there is a substantial I-section cast-iron lintel over a blocked opening to the east that appears to represent an early alteration. Original openings have been blocked, as have those of the west return wall of the rag store block.

The interior of the main block was originally divided into four aisles by three axial rows of iron columns on an eleven-bay grid. The west bay to north of centre was always set apart within brick walls as the engine house. This is entered from the south. The steam engine has gone, but there are bearing boxes in the east and west walls. There is the ghost of steps and a surviving bracket in the wall to the southeast that are presumably traces of a staircase that led to a beam gallery and thence to the first floor. There is also evidence of the flywheel position to the north on the east wall. Adjoining the engine house to the east is a three-bay area that was drawn in 1856 as having two rows of eight columns. All trace of these has gone, but such dense columniation suggests support for a heavy object, perhaps a water tank.[19] Two blocked and apparently secondary openings in the north wall here have unusually high sills, possibly reflecting the height of a tank.

The principal bearing box in the engine-house east wall is in line with the northern row of the main columns, all but the two easternmost of which have been removed. The main drive

shaft must have run along these columns, on the south side to judge from brackets on the survivors and a drawing.[20] The bolting face over the brackets is at precisely the same height as the bearing box (3.3m above the floor). Secondary shafting must have run southwards in multiple lines as there are brackets about 50cm lower on the east and west sides of the central row of columns. A separate drive shaft from the engine house is suggested by a smaller bearing box near the south end of its east wall. This may have run to three columns south of the water tank position[21] with secondary line shafting running south to serve the bays south of the tank and engine house, an area that was a percussion cap factory by 1866 if not originally.[22]

The basic structure of the building's internal iron frame is not unlike that of numerous contemporary and somewhat earlier industrial buildings, notably textile mills. The ironwork here is striking, however, for its robustness and elegance of form (Isometric view). There was little standardization in the design of iron components for buildings in the 1850s. Details of the frame are distinctive and worthy of note.

The cast-iron columns are 23-27cm in diameter on the lower level, 16-19cm on the upper level. They are octagonal in section with moulded caps and bases. On the lower level the central row of columns has a notable feature in vertical oval openings just below the caps lining through from east to west. These are lipped and under the west-facing openings there are substantial brackets with paired bolt holes. The shape of these openings suggests twin pipes running down the centre of the building, stabilised by clasps from the brackets. Such pipes might have connected a water tank to pulping vats. Their presence would not rule out simultaneous use of the supporting columns as downpipes from the central valley of the roof,

for which internal plastic drainpipes appear to be a recent substitution.

Much of the cast-iron frame for the floor to the upper level has been removed and most of what does survive is concealed by suspended ceilings to the south and east. However, enough is visible to ascertain the nature of the frame; in some respects the removal of fabric helps to reveal its construction. The frame comprises beams of two types, axial (east-west) and cross (north-south), with axial joists. These members all have an I-section and parabolic lower flanges. The beam ends are extruded to clasp octagonal connecting blocks between the lower column caps and upper column bases, with half-round lugs from the ends of the clasping sections meeting to allow linkage by means of wrought-iron shrink rings. The axial beams are, in the main, 5.3m long, and 31cm deep except at their ends which are deeper. The cross beams are 6.15 to 6.4m long and 46cm deep, to accommodate brackets for joists, two across each bay. The lower flanges of many of the visible beams have grouped bolt holes, usually within markings for square plates. These bolts and plates seem to have been concentrated in positions such as to indicate that they relate to additional brackets to support drive shafting. The axial beams along the centre of the building have some irregularly spaced holes in their lower flanges, possibly for support of the water pipes. Regular holes in the upper flanges of the axial beams correspond in terms of interval and level with similar holes in the joists to indicate that the flooring was bolted or nailed onto the axial beams and the joists. No original flooring survives, but if it was timber boards, as the 17cm spacing of the holes suggests it was, the boards were exposed to the ground floor. The factory would not therefore have been 'fireproof', perhaps a low priority where the process required large volumes of water. The removal of the floor to the north probably relates to the conversion of this part of the building to use with an overhead travelling crane, that in place is on a steel

gantry and was made by Herbert Morris Ltd with a 3-ton capacity.

In one of the 1856 drawings narrow staircases are sketched against the inside of the south and east walls,[23] but no evidence of these having been built is visible, except in so much as two existing 20th-century staircases near the row of columns to south of centre appear to re-use 19th-century handrails. There are no indications that there was originally machinery on the upper storey. It appears to have been a large open space, divided perhaps by timber partitions and, under the central valley, by an elegant cast-iron arcade of slender columns to axial arched beams with open spandrels. The upper level was later fitted with drive shafting and light machinery, probably c1884 when the building was converted to metal cartridge production (see above).

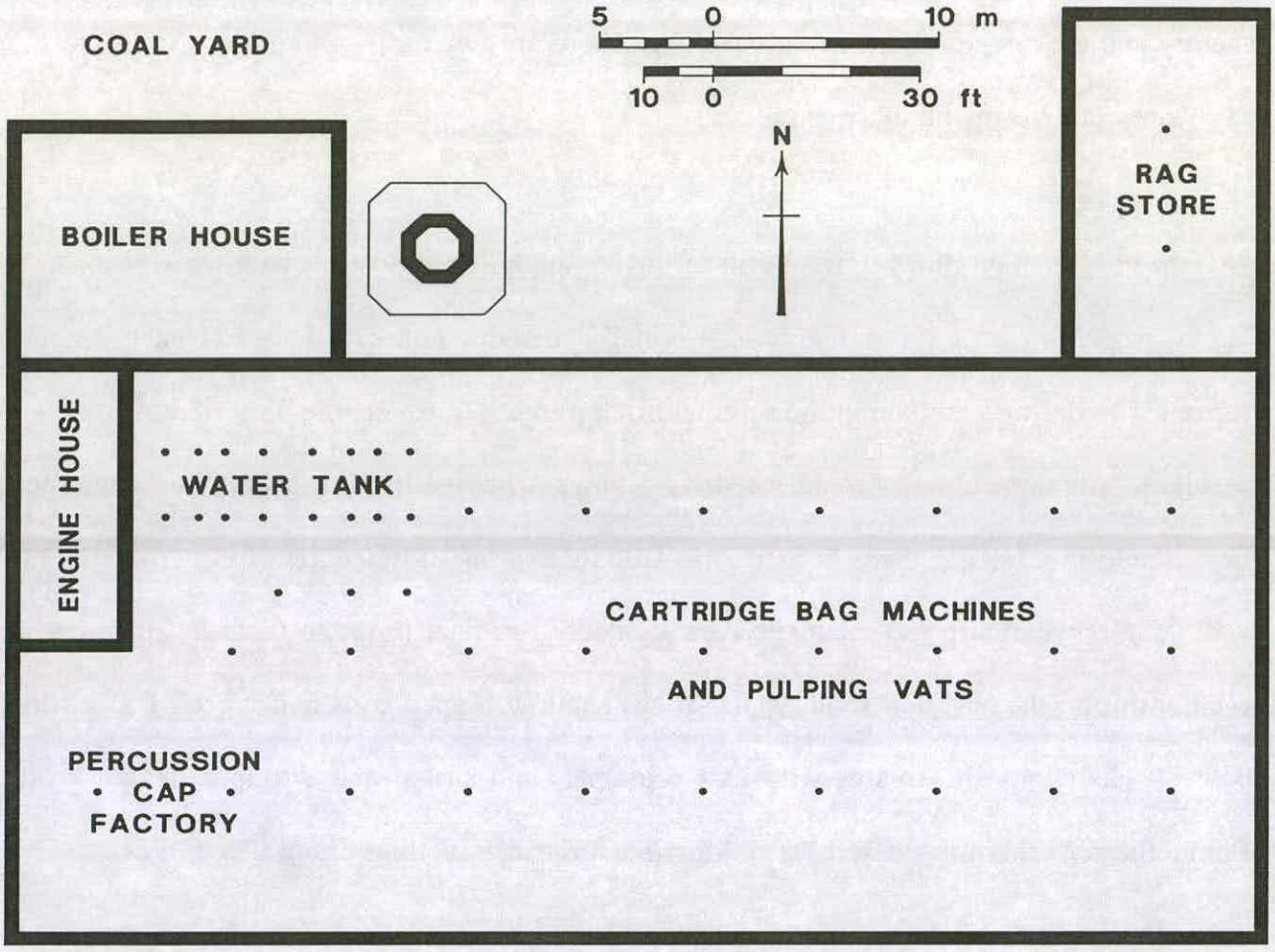
The roof is in two 12.6m spans, each framed in iron in 16 bays with hips at the ends. The north roof trusses survive unaltered, the south side has had six trusses towards the east replaced in steel. The composite trusses have I-section cast-iron principals with integral openwork 'circle struts'. The other members of the trusses are thin circle-section wrought-iron. The hips have similar half trusses diagonally set. Octagonal honeycomb castings at the apex of each truss provide bolting faces for the principals, king rods and I-section cast-iron ridge plates. The trusses are also linked at tie level by axial wrought-iron tension rods. Each principal has numerous bolt holes along its upper flanges, presumably for slender iron purlins. Removed, these would probably have supported timber boarding under slates.

The former rag store block to the northeast communicates with the main block via an internal door. This appears to be an insertion.[24] There was probably no direct link between the

factory and the rag store as a fire precaution. There are two cast-iron columns in the former rag store. The beams here are cased.

Attached to the main block to the north of the engine house and water tank there is a single-storey workshop in a space that was originally a boiler house.[25] This has been recently refronted to the west, retaining the original brick plinth. However, the boiler house east wall survives, with three blocked round-headed openings. The five-bay north wall has been rebuilt in concrete blocks, but there is a fragment of its external cornice returning from the east wall. The boiler house roof also survives, evidently original to judge from its form and its relationship to the east and south walls. It has shallow hipped ends and is iron framed in 3 bays. It has composite trusses with cast principals and struts, and wrought ties and rods. Below the roof there is a 5-ton Davy Morris overhead travelling crane dated 1986.

The site of what was originally a walled coal yard to the north of the boiler house has been built up. The external wall to the west and the internal fabric are recent, but a stock-brick return wall with blocked openings a short distance north of the former boiler house appears to survive from the 'iron shop' of c1884.[26] The east wall of the former boiler house was extended northwards to join the 'iron shop' south wall with a wrought-iron girder forming the lintel to a blocked opening. The open yard to the north of the Paper Factory was originally enclosed by low walls and the Royal Laboratory offices (Building 18).[27] A tall chimney in the southwest corner of the yard has gone. This area, entirely built up by 1944,[28] is covered by twin-span steel-framed roofs and 5-ton overhead travelling cranes made by Herbert Morris and Babcock & Wilcox.



Building 17: Diagrammatic ground plan reconstructing original layout (based on PRO, WORK 43/1615)

Functional Layout

The evidence of the building fabric combines with an account of the work of the Paper Cartridge Factory written by Andrew Wynter, MD, and published in the Quarterly Review in 1858 to make a good understanding of the original processes and layout possible (Diagrammatic ground plan). The 1858 account is reproduced in full as an appendix to this report.

Initially, rags, the major raw material for paper making prior to 1860,[29] would have been brought to the rag store in the separate northeast block. These rags would have been cut and boiled, probably by women and children, either in the room over the rag store or at the east end of the main block.[30] The main part of the ground floor of the main block, at least bays three to seven from the east end, was given over to large vats of water, possibly 10 or 15 in number. The rags would have been pulped by beating engines in the vats. The making of the paper cartridge bags by drying machines over these pulping vats is graphically described by Wynter.

The west end of the ground floor to the north was given over to the engine house and, it would appear, to a water tank. The engine powered line shafting for all the building's machinery and perhaps also pumped water along pipes through the central row of columns to the pulping vats. There was extensive underfloor drainage.[31] From at least 1866, if not originally, the western bays to the south on the ground floor of the building were a percussion cap factory.[32] Wynter's account describes percussion cap making in a nearby Laboratory Department building. Percussion caps were manufactured at Woolwich from 1841.[33]

The technological advances manifest on the lower floor did not preclude intensive use of child labour on the upper floor, for the manual assembly of paper cartridge bags. This too was tellingly described by Wynter.

Appendix: An 1858 Account of the Paper Cartridge Factory in Use

The following account, which starts in a Royal Laboratory building near the Paper Cartridge Factory, is taken from 'Woolwich Arsenal and its Manufacturing Establishments', written by Andrew Wynter, MD, and published in the Quarterly Review, January to April 1858. Much of Wynter's information derived from an 1856 report by John Anderson, Inspector then Superintendent of Machinery at the Arsenal, 'General Statement of the Past and Present of the Several Manufacturing Branches of the War Department'.

> 'The first process in this light and delicate work is the stamping of sheet-copper into pieces of the required form to make the caps. For this purpose the copper is placed beneath the punch of the machine, and immediately it is put in action, small crosses of metal are seen to fall from it into a box in a continual stream, whilst the sheet itself is transposed by the punching process into a kind of trellis-work. These crosses of equilateral arms are now transferred to another machine, which instantly doubles up the four arms, and at the same time so rounds them, that they form a tube just the size of the gun-nipple, and by a third operation of the same machine a kind of rim is given to the free end, which makes the cap take the form of a hat. This rim marks the difference between the military and the ordinary percussion-cap - the soldier, in the hurry and confusion of battle, requiring this guide to enable him to apply the proper end to the nipple. The metal portion of the cap completed, it is transferred to a man who fills it with detonating powder. As this is a very dangerous process, the artisan upon whom the duty devolves sits apart from the boys, who perform all the other work, for fear of an accidental explosion. To fix the fine dust in the cap, a very pretty machine is employed, which gets through its work with extreme rapidity. The caps are placed in regular rows in a frame-work, to which is attached a lever, armed with as many fine points as there are caps in a single row. The motion given by the hand alternately dips these fine points into a tray of varnish, and then into each succeeding line of caps. When the varnish is dry, the powder is fixed and effectually protected from the effects of damp. The caps are now finished, and are ready for the boy who counts and packs them. Machinery is even employed to perform the part of cocker, and with one gentle shake does the brain-work of many minutes. A frame is constructed, into which fit a number of small trays, each tray being pierced with seventy-five holes. Upon this frame the boy heaps up a few handfuls of caps, and then gives the whole machine a few jerks, and when he sees that every hole is filled with a cap, he lifts out each separate tray and empties it into appropriate boxes. In this manner he is enabled, with extreme rapidity, to count out his parcels of seventy-five caps, the regulation number served to each soldier with sixty rounds of ball-cartridge - the excess of fifteen being allowed for loss in the flurry of action. The

British soldier's clumsy fingers are by no means well calculated for handling and adjusting such light articles.

Equally curious with the production of caps is the manufacture of cartridge-bags. The visitor, as he mounts the stairs to the upper floor of a large building close at hand **[BUILDING 17]**, is made aware by the hum and collision of shrill young voices that he is approaching a hive of children, and as he rears his head above the banisters, he finds that he is in the midst of a little army of urchins, varying from eight to fourteen years of age, seated at long benches rolling up paper cartridge-bags. This process requires some little nicety, as each bag is made up of three distinct papers of different sizes and shapes, which have to be neatly adjusted round a roller one upon another. By long practice some of these little fellows complete the operation in a surprisingly short space of time - rolling, twisting in the end, tying, and drawing it from the rod almost as quickly as you can look at them, the swaying of the body during the operation giving to the entire mass of eight hundred children a most extraordinary aggregate movement as the room is surveyed from one end to the other. Some boys are infinitely more nimble-fingered than others, and the sharpest earn eight or nine shillings a-week at the work.

Nimble as their little fingers ply, however, the hands of machinery laugh them to scorn. In the room below we note as we descend strange wheel-like frames revolving horizontally, and others working up and down into tanks of paper pulp. These are the new machines destined to supplant the little children over-head, and to hush the ceaseless hum of their human labour. Throughout the entire range of the Arsenal there is no sight more interesting than is exhibited by these machines, the *modus operandi* of which is extremely simple. Circles of brass tubing have short upright tubes inserted into them at regular distances. These upright tubes, or fingers, are pierced with fine holes, and the whole apparatus is attached to an exhausting-pump. Worsted mittens are fitted to the fingers, and when all is ready, the Briarean hand is dipped into the bath of pulp, the air in the tubes is withdrawn, the liquid necessarily rushes towards the fingers, and the water passing through, leaves the pulp adherent to the mitten. The process is instantaneous, hand after hand drops into the trough, gloves its fingers with pulp, and rises with a thousand cartridges in its grasp, quicker than one of the boys up stairs has finished a single bag. The process is not complete, however, until they are dry. Each mitten is removed from its metal finger, and placed on a similar one heated with steam. In ten minutes the desiccating process is finished, and the cartridge-bag is removed, a far more perfect instrument for its deadly purpose than that which is made up stairs by hand. The hint for this beautiful machine was taken from the apparatus employed for making conical seamless sugar-bags without the intervention of the paper maker - so diverse are the developments which may spring from the same idea. Of these small-arm cartridge-bags, 400,000 can be manufactured in a day of ten hours; but as each cartridge is composed of a double envelope, one fitting within the other, in order to separate the conical ball from the powder, the product furnishes 200,000 cartridges - an enormous quantity, but scarcely equal to the demand of such campaigners as Havelock, whose men, day by day, consumed their sixty rounds per head. At first sight it seems strange to find the Government turned paper makers, and the visitor may think that these bags could be obtained, as the sugar-bags are by the grocers, from the private manufacturer, but it is absolutely necessary that they should be produced side by side with their deadly contents. They are far more delicate things to maintain in their integrity than even

wafer-biscuits, which they very much resemble, and they are required in such enormous numbers, that any mechanical impediment, such as crushing, interposed to the filling of them with powder and ball, would add immensely to the expense. The pressure in packing necessary to convey them to the Arsenal would flatten, and hence destroy them.' (Quarterly Review, Jan. 1858, pp. 261-4).

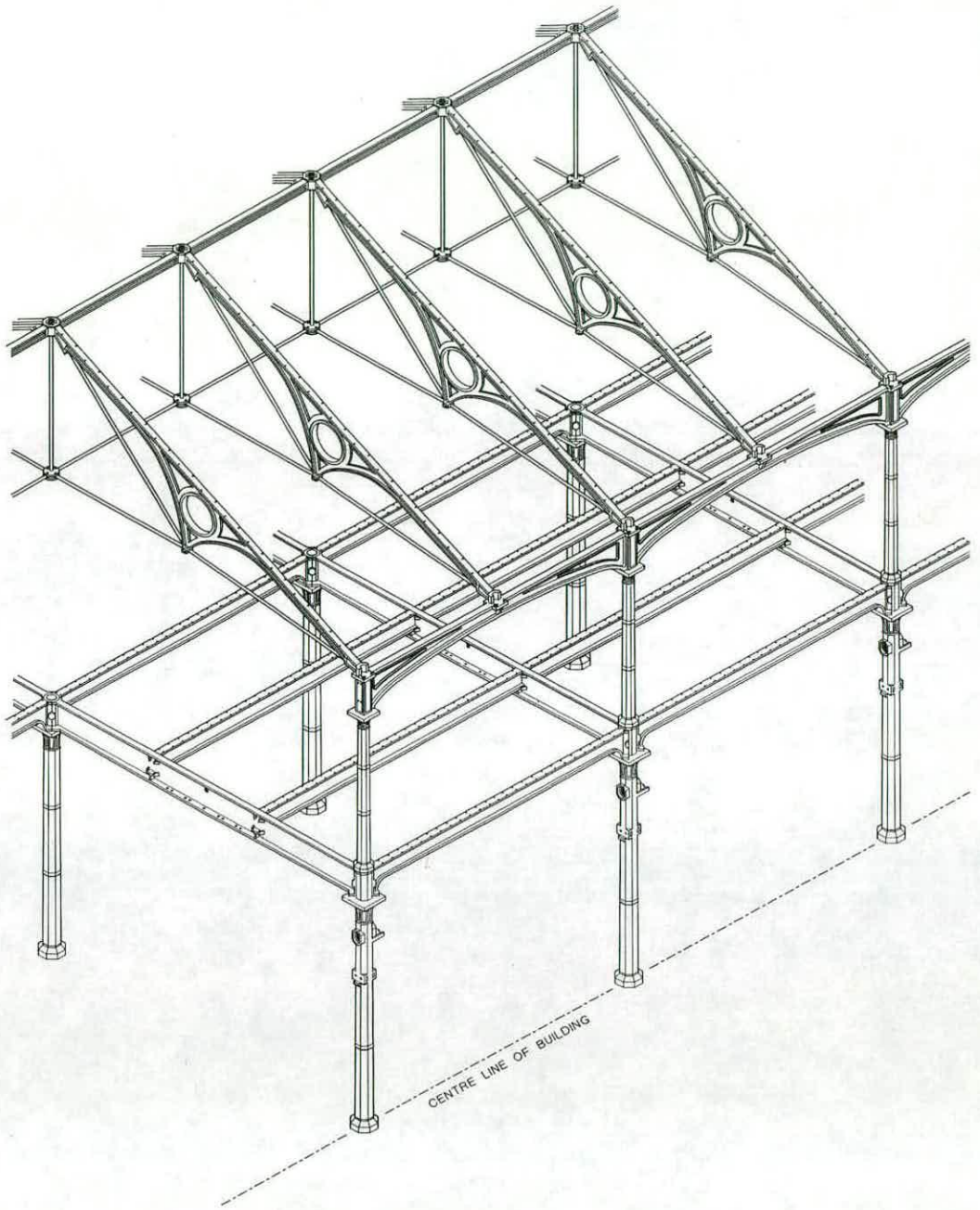
Notes

1 - Public Record Office, WORK 43/515, Map of the Royal Arsenal, Woolwich, 1932.
2 - Brigadier O. F. G. Hogg, The Royal Arsenal: its Background, Origin, and Subsequent History, 1963, vol. ii, pp. 781-3: PRO, WORK 43/1302, plan of Laboratory Committee Improvements, 1853/4.
3 - PRO, WORK 43/1510-16, 1612-15, plans, sections and elevations of the Paper Factory.
4 - Hogg, ii, p. 768.
5 - Quarterly Review, Jan.-April 1858, pp. 261-4.
6 - Hogg, ii, p. 765.
7 - J. Weiler, 'The Making of Collaborative Genius, Royal Engineers and Structural Iron 1820-70', The Iron Revolution, exh. cat., 1990, pp. 41-4.
8 - Hogg, ii, p. 817.
9 - The Engineer, 23 Sept. 1881, p. 218.
10 - The Engineer, 2 Oct. 1891, p. 269.
11 - PRO, WORK 43/506.
12 - Album of Views of Woolwich Arsenal, n.d., publ. Gale and Polden: Hogg, ii, p. 902.
13 - PRO, WORK 43/1612.
14 - PRO, WORK 43/1613-14.
15 - PRO, WORK 43/1614.
16 - PRO, WORK 43/501, Map of the Royal Arsenal, Woolwich, 1866.
17 - PRO, WORK 43/1615.
18 - PRO, WORK 43/506 & 515, Maps of the Royal Arsenal, Woolwich, 1888 and 1932..
19 - PRO, WORK 43/1302 & 1615.
20 - PRO, WORK 43/1614.
21 - PRO, WORK 43/1615.
22 - PRO, WORK 43/501.
23 - PRO, WORK 43/1615.
24 - Ibid.
25 - Ibid.
26 - PRO, WORK 43/506.
27 - PRO, WORK 43/1612 & 1615.
28 - Map of the Royal Arsenal, Woolwich, 1944; held on site.
29 - D. C. Coleman, The British Paper Industry, 1495-1860, 1958.
30 - C. Tomlinson, 'Paper' in Cyclopaedia of Useful Arts etc, 1854, vol. ii, pp. 357-74: PRO, WORK 43/1302.
31 - PRO, WORK 43/1615.
32 - PRO, WORK 43/501.
33 - Hogg, ii, p. 675.

Recorded by Andy Donald, Peter Guillery and Derek Kendall
June 1994

Report by Peter Guillery
September 1994

LIST OF ILLUSTRATIONS

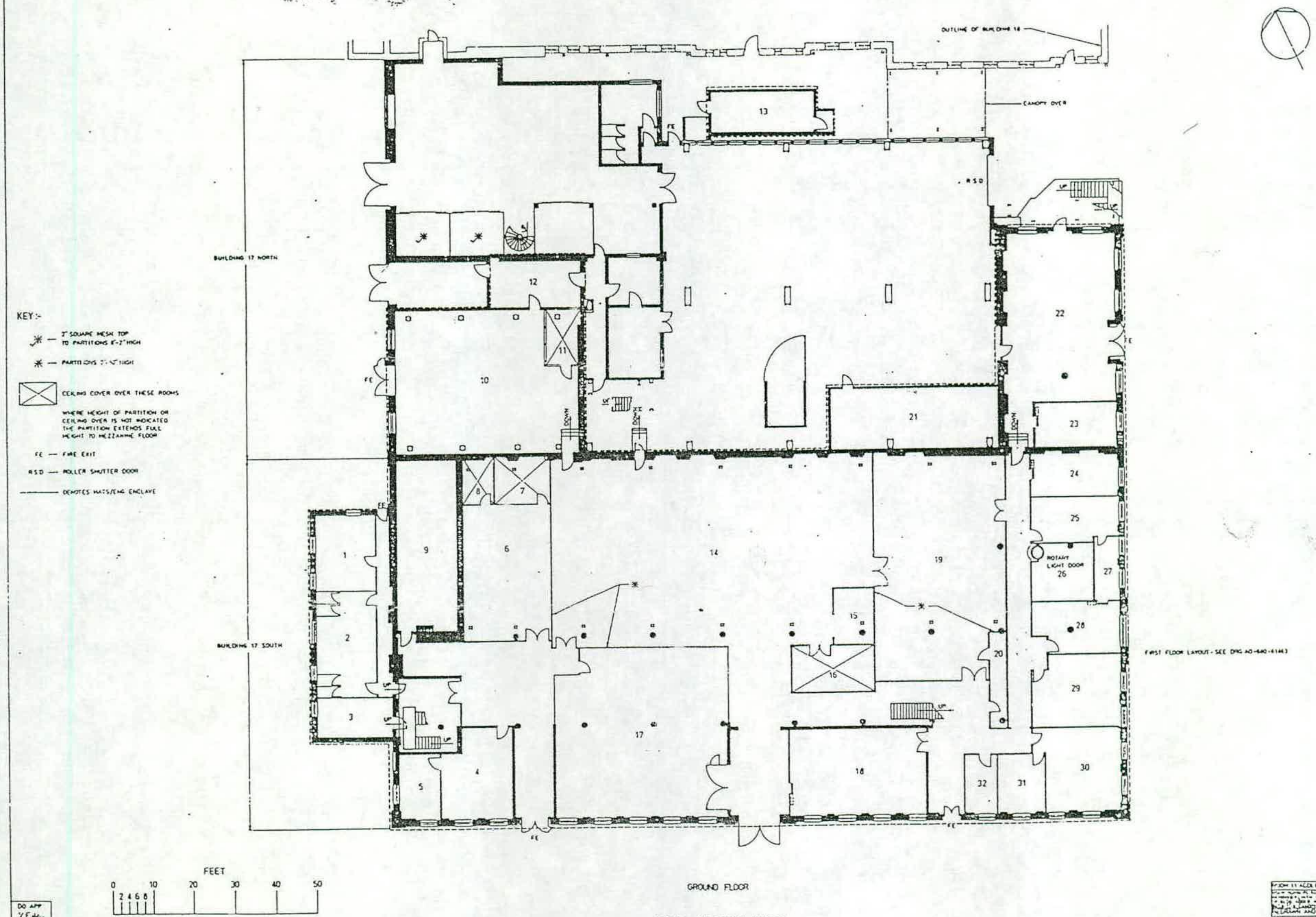


ISOMETRIC VIEW OF TWO BAYS OF INTERNAL IRON FRAME
FROM NORTH EAST (JOISTS RECONSTRUCTED)

BUILDING 17 (FORMER PAPER CARTRIDGE FACTORY)
Royal Arsenal Woolwich London SE18

Borough of Greenwich
Surveyed June 1994
Drawn Scale 1:50
Grid Reference TQ 440 793
NBR No. 92394
Drawn by A.D.

RCHM
ENGLAND



GROUND FLOOR

ROYAL ARSENAL WEST
BUILDING 17

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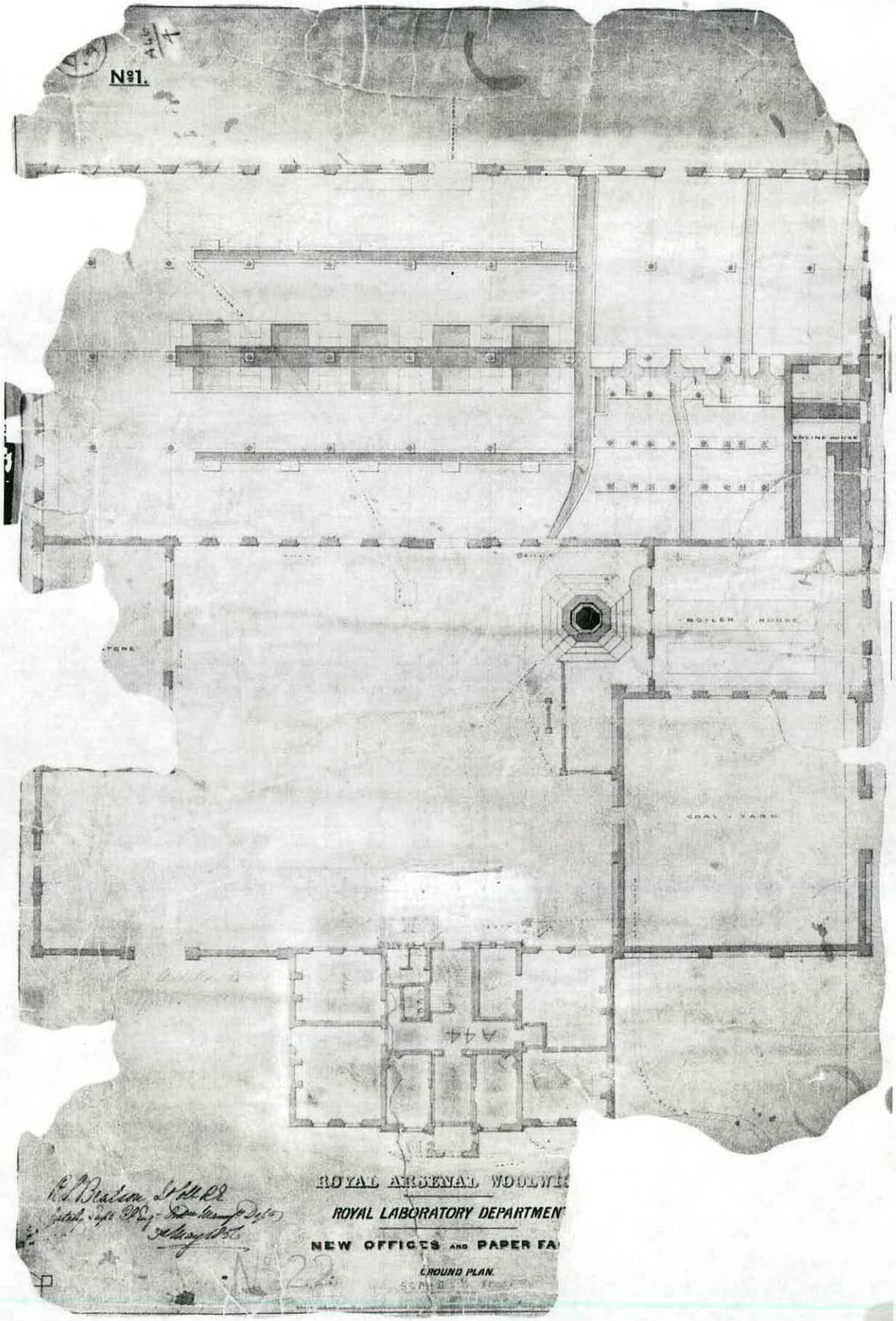
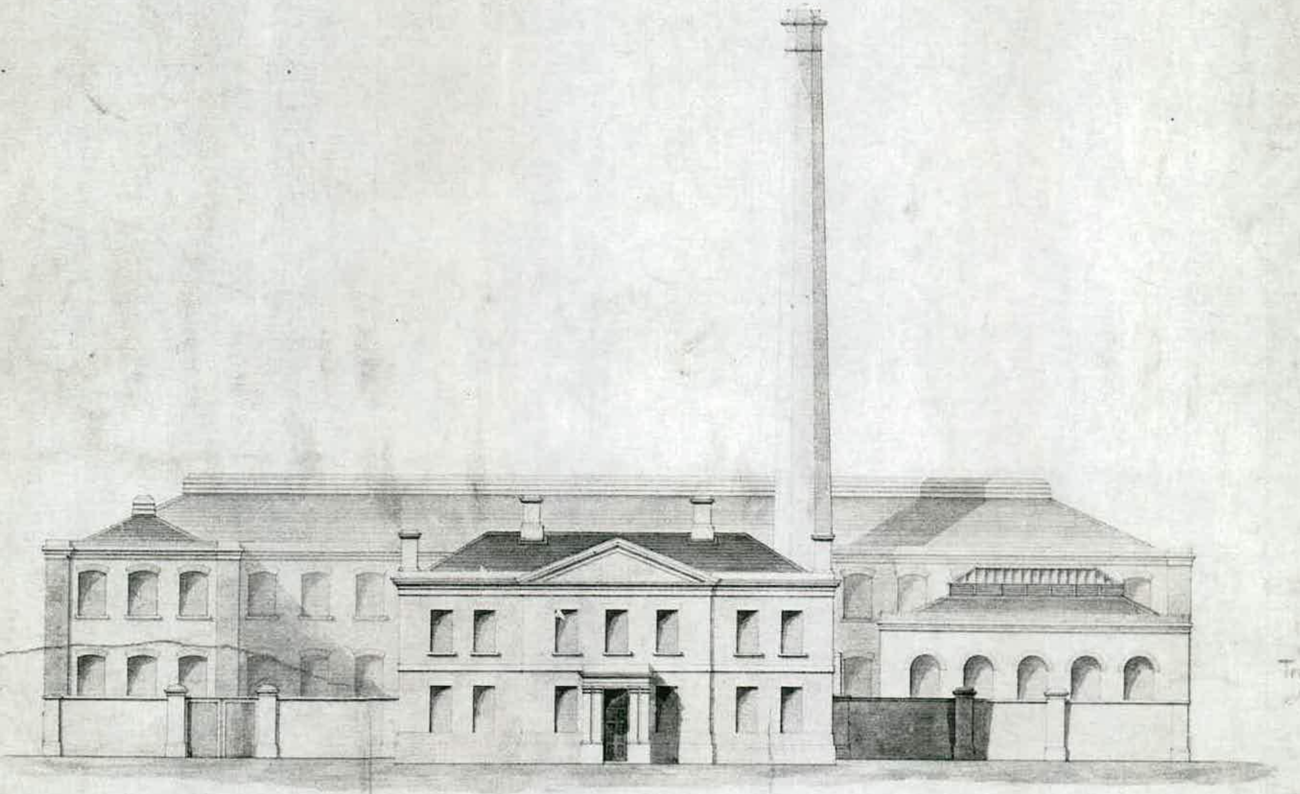

No1.
BOILER HOUSE
COAL YARD
A44
ROYAL ARSENAL WOOLWI
ROYAL LABORATORY DEPARTMEN
NEW OFFICES AND PAPER FA
GROUND PLAN.

No. 2.



ROYAL ARSENAL WOOLWICH

ROYAL LABORATORY DEPARTMENT.

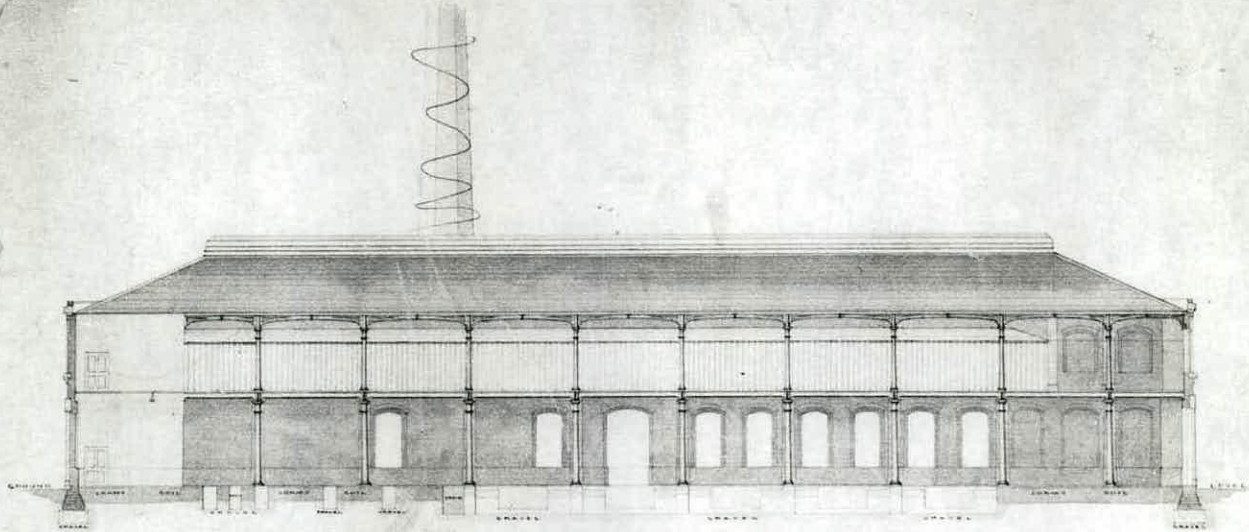
ELEVATION of NORTH FRONT of OFFICES and PAPER FACTORY.

R. S. Beatson Lt. Col. R.E.
(lately Supt. Rl. Engn. Ordce. Manuf. Depts.)
3rd May 1856

A 44

APPENDIX (i)
ANNEXURE 2

No 3.



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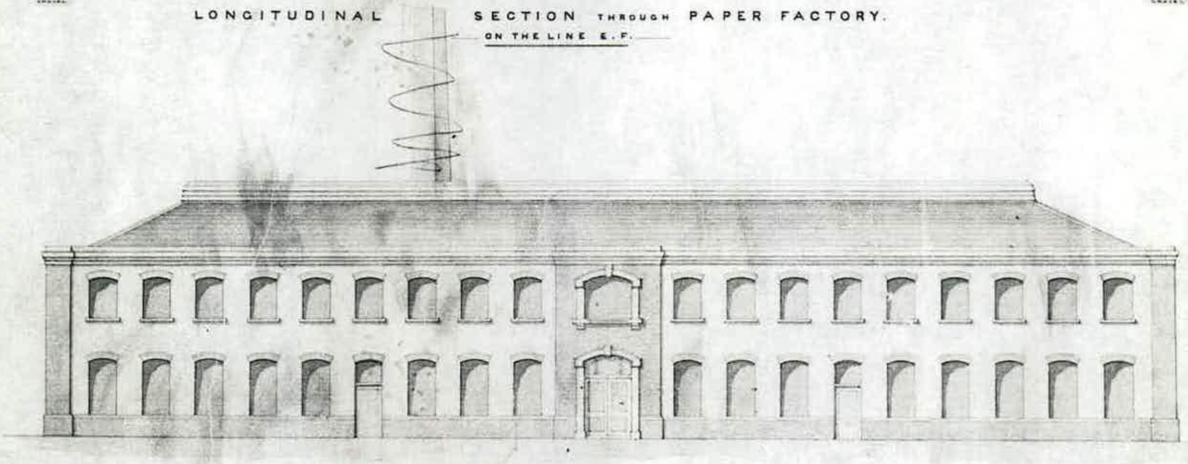


R. S. Beatson Lt Col
(lately Supt R.L.
3rd Sept. 1855.

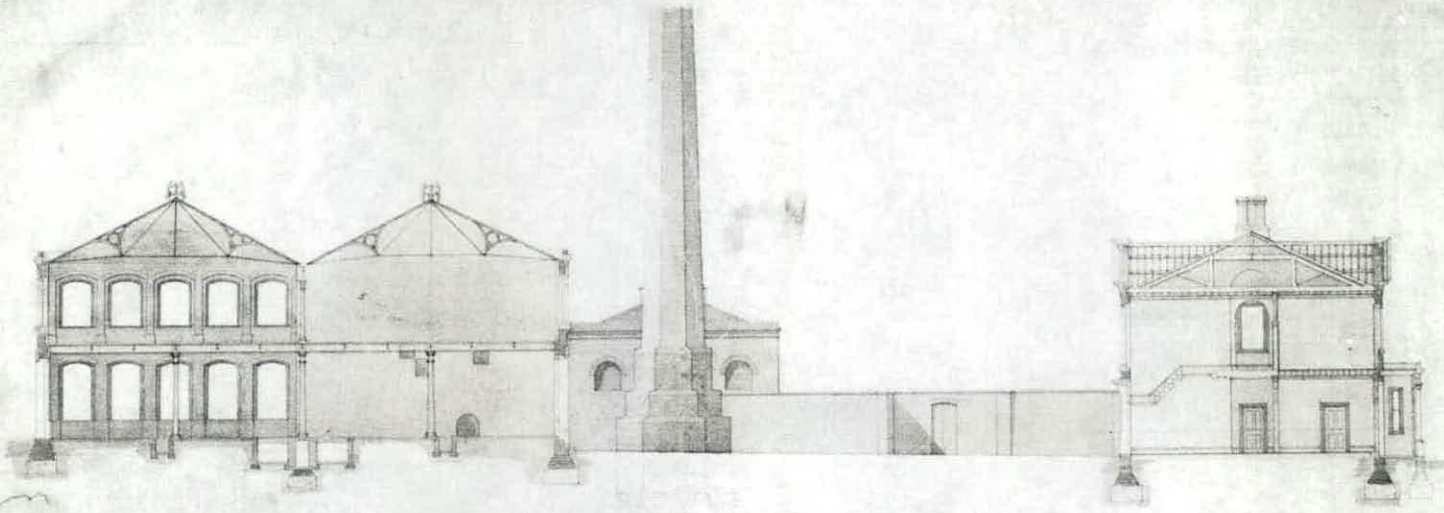
ROYAL ARSENAL WOOLWICH.

ROYAL LABORATORY DEPARTMENT.

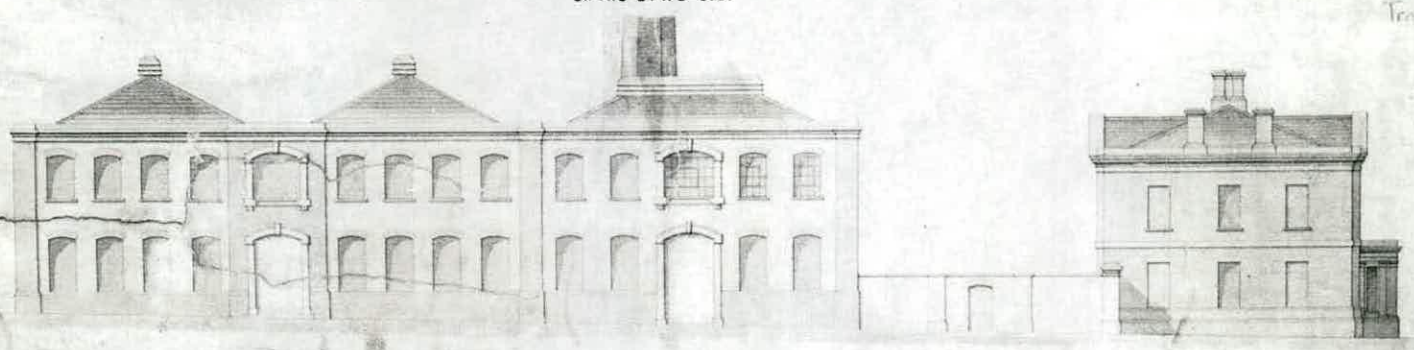
ELEVATION OF SOUTH FRONT OF PAPER FACTORY.

No 24

No 4.



SECTION THROUGH PAPER FACTORY AND OFFICES.
ON THE LINE C.D.

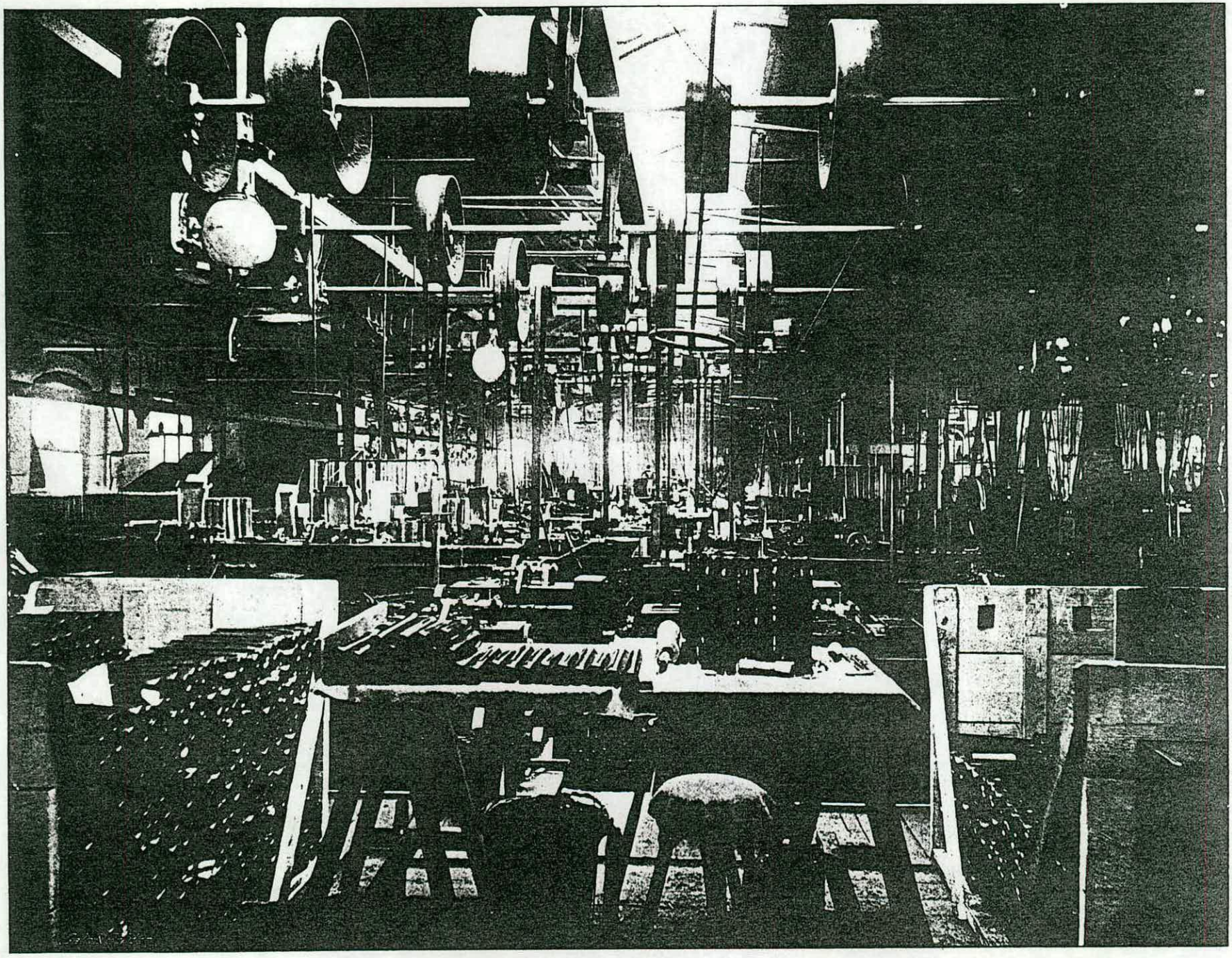


ROYAL ARSENAL WOOLWICH

ROYAL LABORATORY DEPARTMENT.

ELEVATION OF EAST END OF OFFICES AND FRONT OF PAPER FACTORY.

SCALE OF FEET



QUICK-FIRING CARTRIDGE FACTORY, No. 1

Cartridge Cases are manufactured here for 6-in., 4.7, and Hodgkiss quick-firing guns

B(as 17

ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

London **NGR: TQ 440 793**

Greenwich **Buildings Index No: 92394**

The Royal Arsenal, Woolwich

Building 25 (The 'Armstrong' Gun Factory)

Summary

The 'Armstrong' Gun Factory is a tall single-storey yellow stock-brick building, with black- and orange-brick dressings, built in an Italianate style and H-shaped in plan. Its roof is supported by iron trusses. It was erected in 1856 to designs by David Murray, engineer, for the Arsenal's Royal Gun Factory Department as a gun foundry for the turning and finishing of gun barrels. The building was originally essentially a frame for six gantry cranes supported on substantial iron piers, two in each of the three ranges. In 1911 the main range was raised in height and internally rebuilt with a larger gantry crane.

Report

Introduction

It became clear after the commencement of hostilities in the Crimea in 1854 that there were shortcomings in the quality and supply of guns for the British army. The guns in use were heavy, unreliable and inaccurate. Moreover, the Government did not have machinery to produce its own guns and was therefore forced to pay the high prices demanded by private manufacturers. In consequence the War Department acquired for the Royal Arsenal at Woolwich,

> a very large number of the most ingenious machines ... from the United States ... while others were procured from the continent and at home by Mr. Anderson, the

superintendent of machinery. In a very short time a powerful factory of the munitions of war sprung into life.[1]

It was determined that cast-iron guns were no longer sufficient and that William George Armstrong's coiled wrought-iron guns should replace them. Armstong devised a method whereby coils of white-hot wrought iron were hammered together to form a gas-tight tube. By welding lengths of tubing together and by shrinking a number of tubes one over the other a stonger, more powerful, yet lighter gun could be produced. By 1871 the Royal Gun Factory at Woolwich, the State's only supplier of guns for Britain, was producing guns of 35 tons in weight.[2]

Description

Building 25 was erected in 1856 as a gun foundry for iron ordnance for the Royal Gun Factory Department to designs by David Murray, engineer, housing machinery to turn, sight and otherwise finish heavy guns.[3] It was apparently temporarily occupied by W. G. Armstrong from 1858 in connection with the adoption by the Government of his designs for weaponry. Armstrong was appointed 'Engineer of Rifled Ordnance' in 1859 and his designs were manufactured at Woolwich until about 1863.[4]

The building consists of a main range, 13 bays long, built on an approximately east/west axis, with two cross ranges, nine bays long by four bays wide, creating an H plan. The area between the cross ranges to the south of the main range is enclosed and roofed over. In height the building is a tall single storey with a later floor inserted and is built in an Italianate polychrome style, of yellow stock brick laid in English garden wall bond, with black- and

orange-brick dressings. In its outward appearance the building is reminiscent of early railway architecture, possibly reflecting railway works sheds as then recent structures built for comparable heavy industry. The openings of the main range are round headed, with prominent 'key stones' formed in brick. The arches of the window heads spring from a string course which runs all around the building and sits on brick corbels. There are massive iron plates between many of the windows at this level, presumably formerly serving to strengthen the internal structure. The elevations of the main range are surmounted by a parapet wall which rests on a corbel table. The main doorway is situated in the centre of the north elevation and is contained within a two-storey porch, three bays wide by two bays deep. Internal support is given by an iron framework and the roof is composed of iron trusses.

The Ordnance Survey map surveyed in 1864 shows that at that time the main range was used partly as a 'gun factory' and partly as a 'sighting room'. The area to the south was in use as the 'shrinking department', where the wrought-iron tubes were shrunk together to build up the thickness of the barrel. The west range was also a 'sighting room' whilst the east was the 'turnery'. By 1867 two lathes, with a bed length of 36 feet, had been installed in the turnery with two more expected. Adjoining the building to the east there was a large forge, now entirely demolished.[5]

A plan datable to 1856 shows no partitions between the main range and the cross ranges.[6] This allowed the easy passing of guns between the ranges. The cross ranges contain upright cast-iron piers, rectangular in plan, which are positioned in a line centrally along their length. The 1856 plan does not show these rectangular piers but rather circular, or possibly octagonal, columns. It is possible that the rectangular columns are a secondary feature added

once the weight of guns began to increase appreciably.[7] However, their apparent integrity with iron framing above indicates rather that they are original and a change of intention. These piers supported the inner longitudinal girders of two gantry cranes which travelled the length of each cross range. By c1900, if not originally, there were also octagonal columns positioned between and just outside the piers giving additional support to the girders.[8] The outer girders were carried on brick piers along the walls. The 1856 plan and the survival of piers in the north wall of the main range would indicate that a similar arrangement of gantry cranes was originally housed in that range also. The Quarterly Review commented in 1858 that,

> travelling cranes, which run upon railways poised in air overhead, command every inch of the [gun] factories, so that cannon of the heaviest calibre for both land and sea service - 98-pounders weighing many tons can be slung from machine to machine with the greatest ease.[9]

The form of the roofs was M-shaped. The original roof trusses have survived in the cross ranges and are composed of wrought-iron rods forming a king rod and princess rods whilst T-section cast-iron members form diagonal struts. A short I-section iron post rises from the head of the T-section principals to support the ridge of louvres. Similar posts rise from the principals above the princess rods and support the wall plates of the louvres. The wrought-iron rod ties of the trusses are supported by the exterior wall and by arched axial beams which have pierced spandrels. Each end of these axial beams sits on a cylindrical cast-iron column which in turn rest on blocks that were bolting faces for the gantry girders on the heads of the substantial rectangular piers. Similar 1850s ironwork survives elsewhere at Woolwich Arsenal (see Buildings 4 and 17).

Originally the area contained by the cross ranges south of the main range was enclosed by a cast-iron arcade and roofed over with corrugated iron resting on iron roof trusses.[10] The arcade was composed of octagonal cast-iron columns with moulded heads from which sprang four-centred arched girders with pierced spandrels. Three bays at the west end were taller than the rest and the arcade of these bays was surmounted by a higher level of arcading formed of round-arched cast-iron girders with pierced spandrels. Comparable ironwork survives in Building 33, the Royal Gun Factory's former Rolling Mill of c1868.

By 1875 use of this area as a shrinking department also incorporated a heavy boring mill.[11] In that year drawings were made in preparation for the entire south enclosure to be raised to the same height as the three west bays. This was achieved by extending the upper level of the arcade across to the east cross range and raising the original roof trusses by 10ft 6ins. The surviving trusses over this area are similar in design to those of the cross ranges and are therefore probably the largely repositioned 1856 trusses. The arcade was also to incorporate a central sliding door.[12] The intention was to house the shrinking department in the five westerly bays and the heavy boring mill in the five easterly.[13]

The front porch is two storeys and incorporates two staircases, either side of the archway, and small rooms, originally offices. The original windows of the porch survive intact and have timber glazing bars which form a geometric pattern of octagons and squares. The parapet wall of the front porch, which is of brick with recessed panels, is an original feature of the building.[14]

The remaining parapet walling of the main range is not original. It was added in 1911 when,

presumably to cope with the ever increasing weight and size of guns, the main range was raised in height and its original south wall was removed.[15] Lattice-steel stanchions were erected to replace the south wall and to carry the south longitudinal girders of a gantry crane of 130-ton capacity which spanned the full width of the main range. A similar structure was inserted to carry the north beams. The present steel-framed roof of the main range would appear to be part of this 1911 refurbishment. It is possible that the arcading of the area south of the main range was removed at the same time and replaced with the present wall.

Maps and drawings do not indicate a source of power associated with the building, but it seems inconceivable that the processes could have been other than steam-powered. An illustration published in the Illustrated London News of April 1862 shows a gun-factory lathe being turned by belt drive.[16] It is not clear, however, where the steam engine was situated. The original drawings show that the south end of the east cross range was similarly fenestrated to the rest of the building. However, presently this area of the building is blind. Corbels and an iron beam, which was possibly used as a transom support for shafting or gearing, may indicate that an engine was housed in this area.

The Royal Gun Factory Department expanded in the 1860s and 1870s in association with the development of much bigger 'Fraser' guns (after R. S. Fraser, manager of the Gun Factory at Woolwich in this period). In 1881 an Admiralty Committee determined that guns should be increased in size and power, and made of steel; although wrought-iron guns were not finally scrapped until 1902. By 1891 the wire gun was gradually being introduced - a technique whereby the barrels of guns were strengthened by having steel wire, more accurately tape, coiled around them. At that time a plan published in The Engineer in 1891

showed that the main range was being used for 'wire coiling'. This was done whilst the gun was being turned in a lathe. The enclosed area to the south was being used as a 'turnery'.[17]

The forges to the east of what had come to be known as the Heavy Turnery had become steel furnaces, not furnaces for forging steel, as Woolwich imported ready cast steel blocks or blanks:

> After ... rough machining the blanks were heated in a vertical furnace to 1,400 degrees Farenheit ... After soaking the blank at the correct temperature, it was lowered vertically into a tank of rape oil, cooled by a water jacket or pipe coils, and kept moving from time to time over some seven hours. Finally annealing was in a similar furnace but at 900 degrees Farenheit.[18]

Further alterations to the building were carried out in 1967-9 when the present floors were inserted and a three-storey steel and glass office block (Building 25A) was added to the south.[19] Building 25 was handed over to the British Library in 1994.

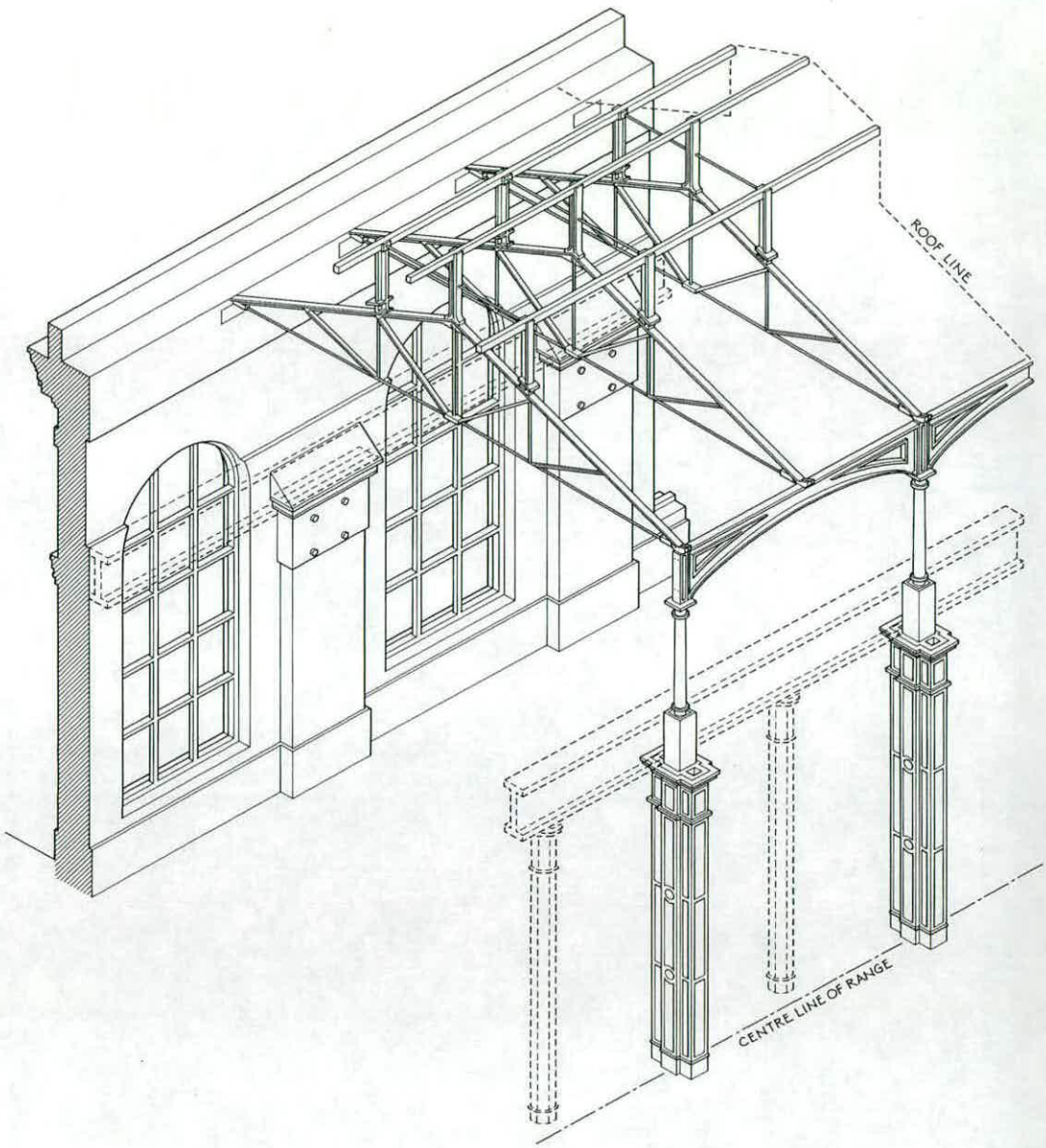
Notes

1 - Quarterly Review, Jan-April 1858, p. 249.
2 - D. H. P. Braid, 'The Armament of Naval Ships in the Nineteenth Century', Transactions of the Newcomen Society, lvi, 1984-5, pp. 113-117.
3 - Public Record Office, WORK 43/1547 (drawing of west elevation, 1856): O. F. G. Hogg, The Royal Arsenal: its Background, Origin and Subsequent History, 1963, pp. 771, 773.
4 - Quarterly Review, Jan-April 1858, p. 250: Braid, loc. cit..
5 - PRO, WORK 43/501 (map, 1864): The Engineer, 8 Feb. 1867, p. 117.
6 - PRO, WORK 43/1546 (plan, n.d.).
7 - The piers have a cast-in design similar to that cast into the iron work of Genappe Mill, Dalton Mills, Keighley, West Yorkshire, which was erected in 1868 (I. Goodall, C. Giles, Yorkshire Textile Mills 1770-1930, 1992, p. 158.).
8 - Album of Views of Woolwich Arsenal, c1900, publ. Gale and Polden: RCHME/NMR, PSA Photographs Collection, G11939/4 (1967).
9 - Quarterly Review, Jan-Apr 1858, p. 249.
10 - PRO, WORK 43/499 and 501 (maps, 1858 and 1864).
11 - PRO, WORK 43/1549 (drawing for alterations, 1875).
12 - PRO, WORK 43/1550 (drawing for alterations, 1875).
13 - PRO, WORK 43/1549.
14 - PRO, WORK 43/1548 (drawing for offices, c1856).
15 - PRO, WORK 43/1553 and 1554 (drawings for alterations, 1911).
16 - As reproduced in Braid, loc. cit., p. 114.
17 - The Engineer, 2 Oct. 1891, p. 269: Hogg, p. 906.
18 - Braid, loc. cit., p. 119.
19 - RCHME National Monuments Record, PSA Collection G12250/2 (1968).

Recorded by Anthony Calladine, Andrew Donald and Derek Kendall, June 1994

Report by Anthony Calladine, October 1994

LIST OF ILLUSTRATIONS

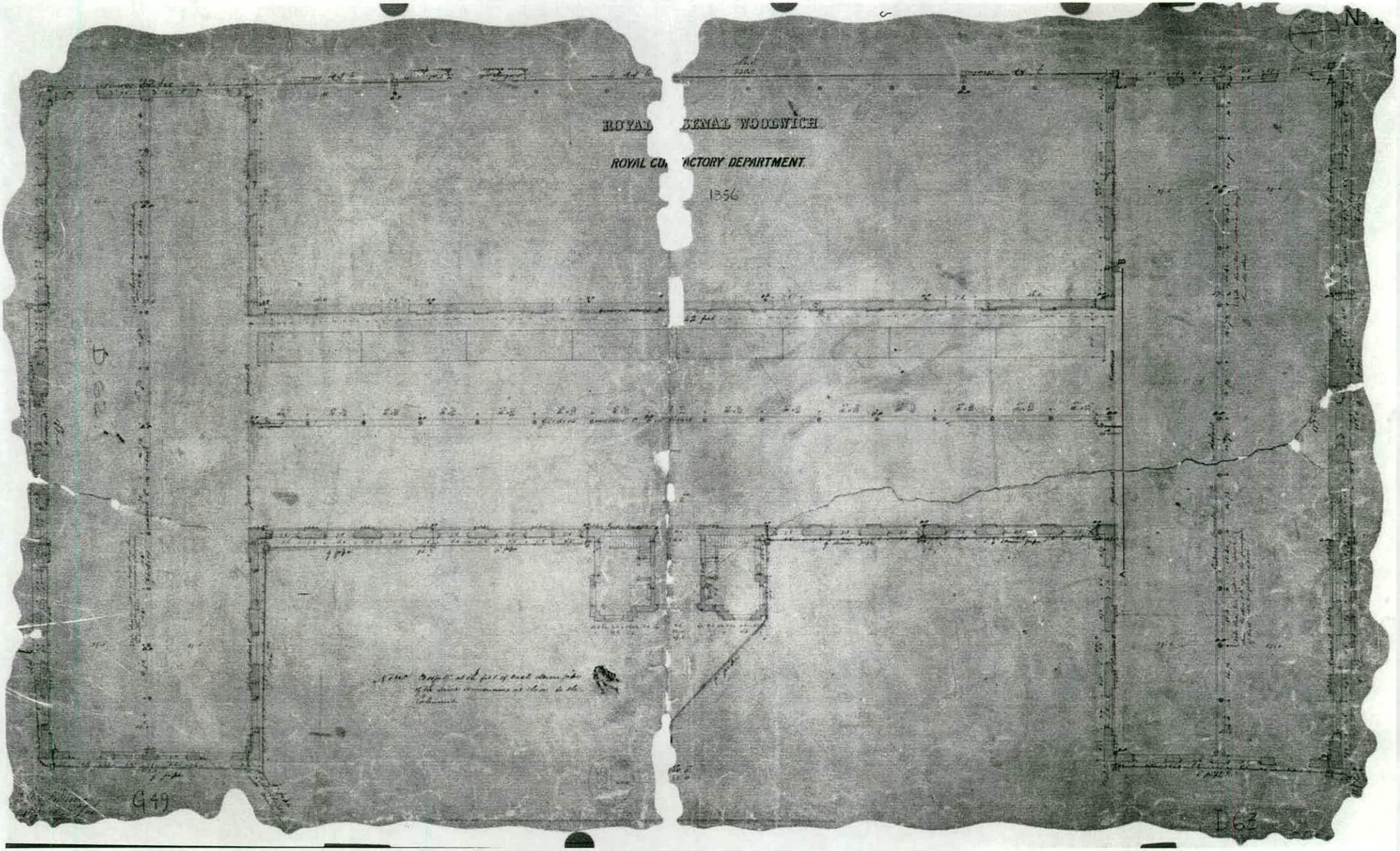


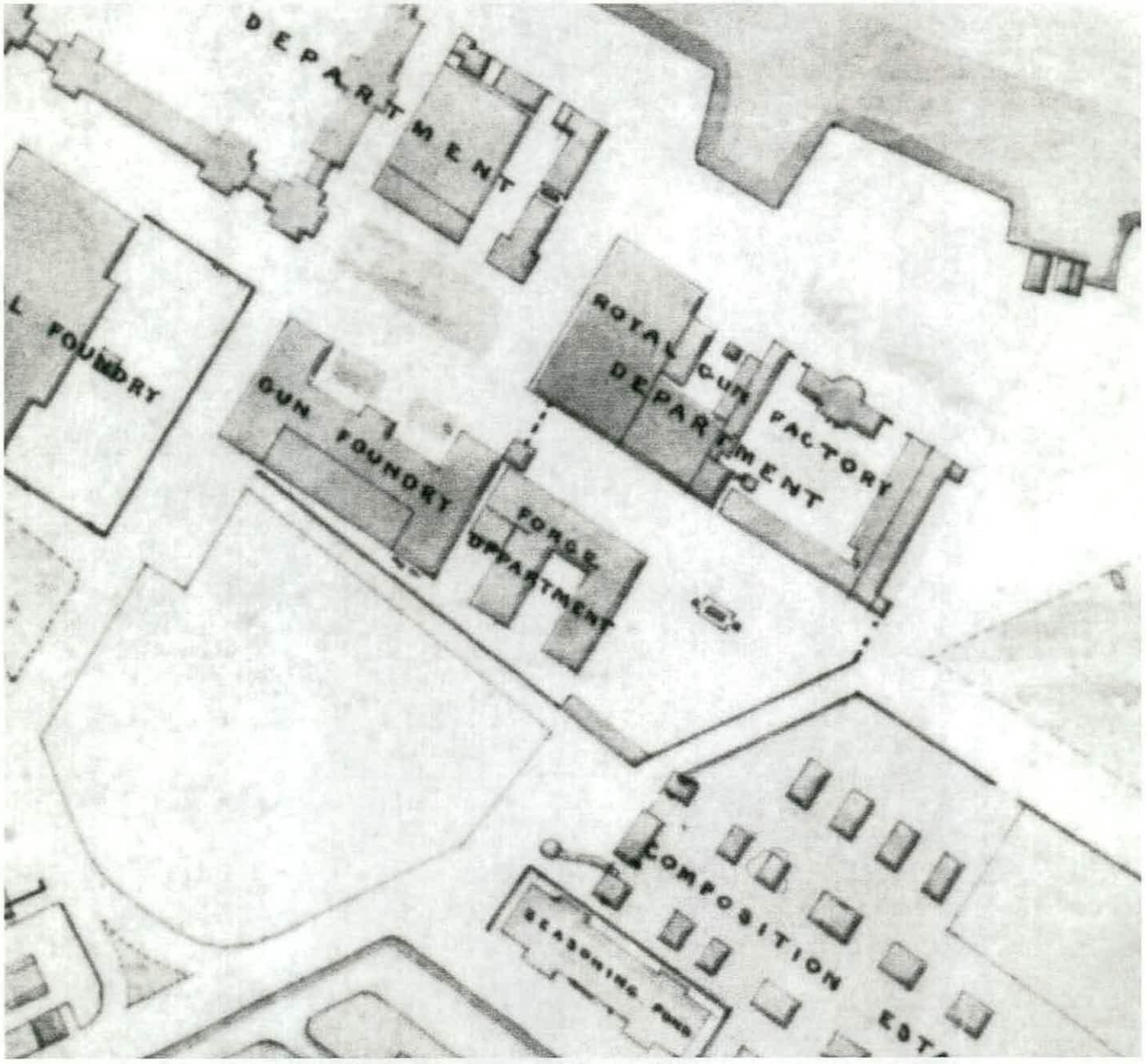
ISOMETRIC VIEW OF PART OF NORTH END OF WEST RANGE FROM NORTH WEST
CRANE GIRDERS AND SUPPORTING COLUMNS RECONSTRUCTED

BUILDING 25 (ARMSTRONG GUN FACTORY)
Royal Arsenal Woolwich London SE18

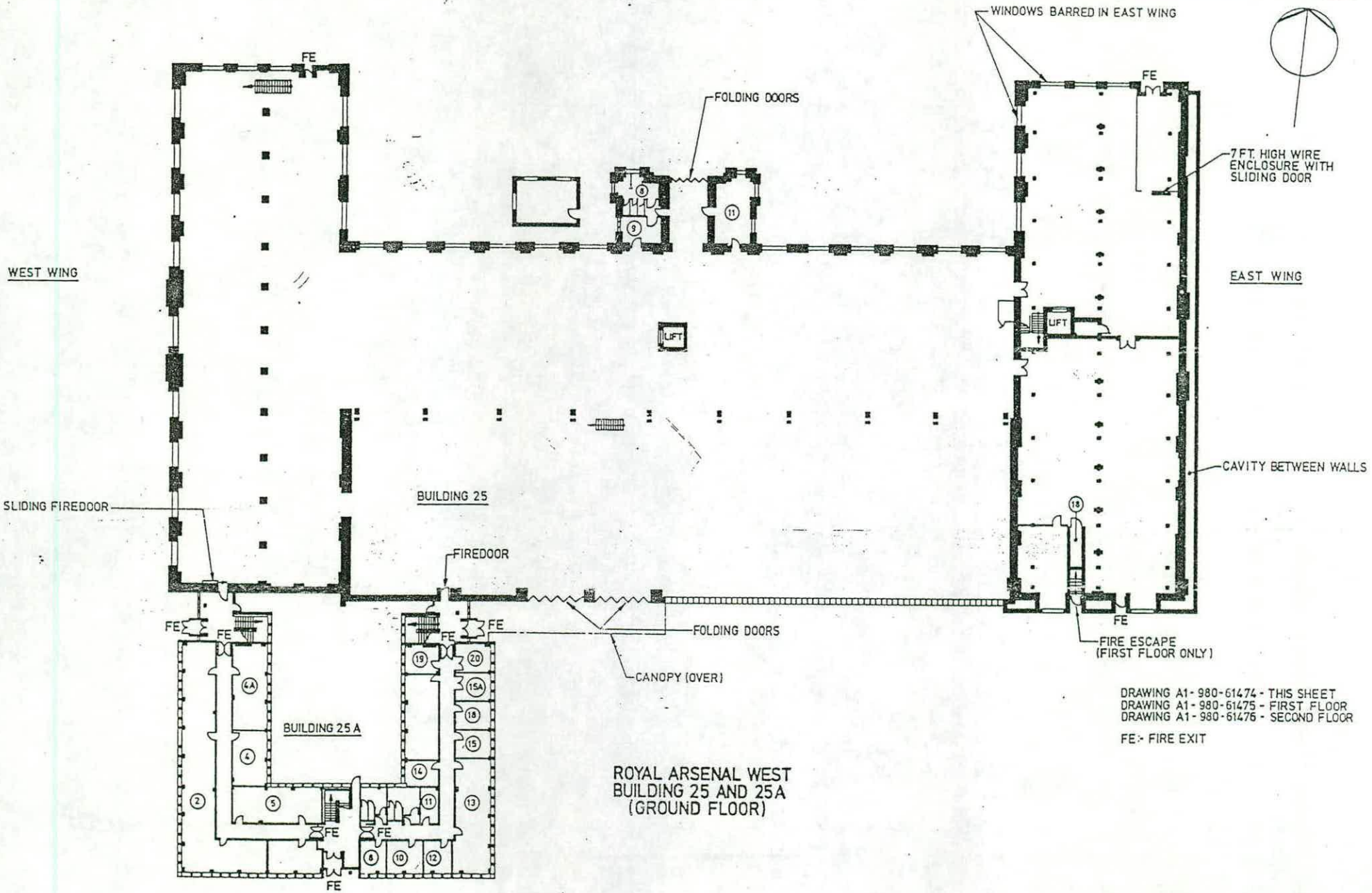
Borough of Greenwich
Surveyed June 1994
Drawn Scale 1:50
Grid Reference TQ 440 793
NBR No. 92394
Drawn by A.D.

RCHM
ENGLAND


ROYAL ARSENAL WOOLWICH
ROYAL GUN FACTORY DEPARTMENT.
1856
N
G49
D62


DEPARTMENT
L FOUNDRY
GUN FOUNDRY
FORGE DEPARTMENT
ROYAL GUN DEPARTMENT
GUN FACTORY
COMPOSITION
SEASONING

 GUN YARD
Coal Yard
Gun Factory Office
NEW FORGE
PROOF SQUARE
Stores
Smithy
Museum
GUN BORING MILL
Artificers Shop
View Room
GUN FACTORY DEPARTMENT
RIFLED ORDNANCE FACTORY
OLD FORGE
Engine Room
Boiler House
Browning Rm
Boiler Shed
FORGE
TURNERY
GUN FACTORY
SHRINKING DEPARTMENT
Ordnance Examining Room
Shell Yard



DRAWING A1-980-61474 - THIS SHEET
DRAWING A1-980-61475 - FIRST FLOOR
DRAWING A1-980-61476 - SECOND FLOOR

FE:- FIRE EXIT

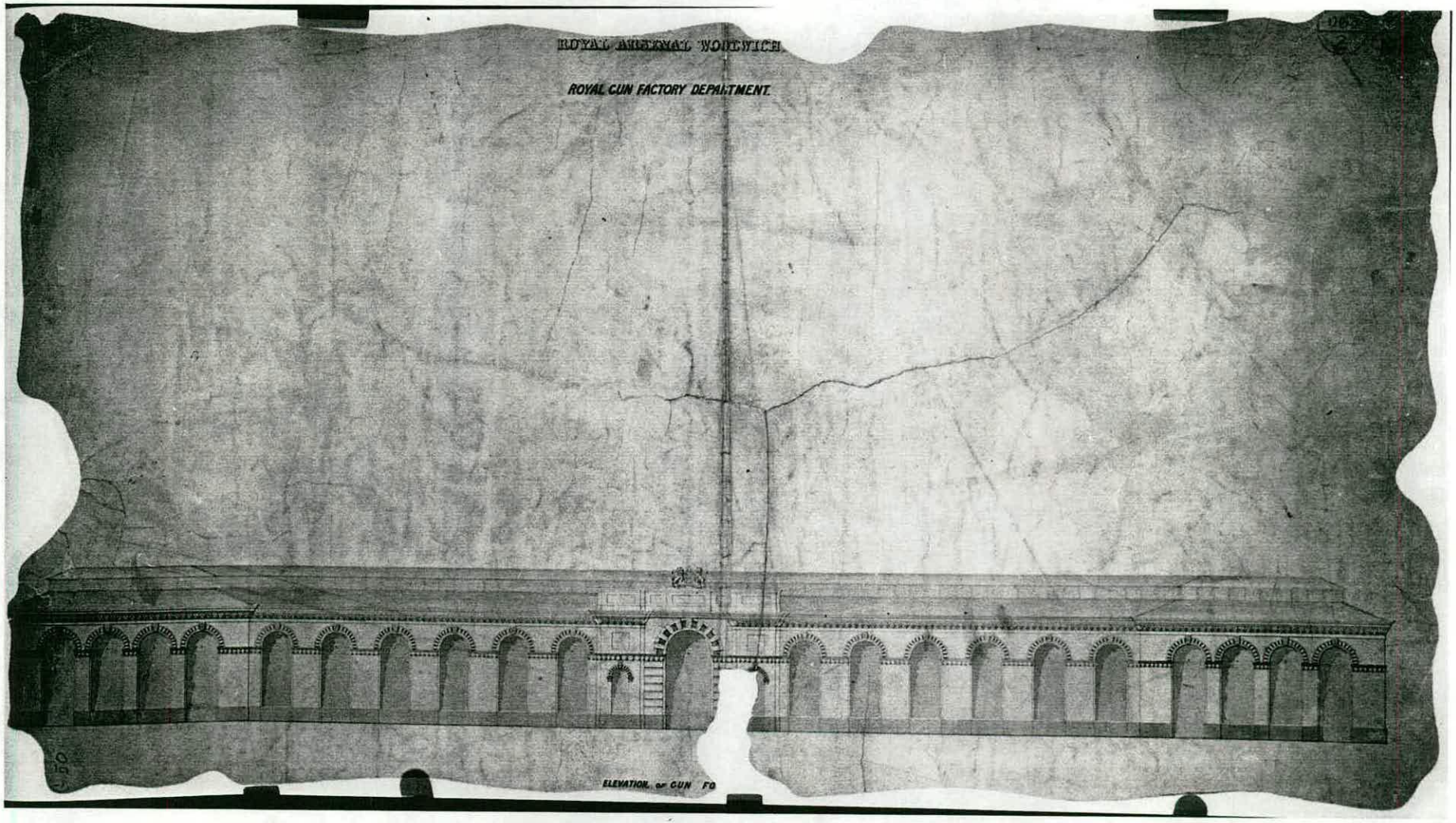
ROYAL ARSENAL WEST
BUILDING 25 AND 25A
(GROUND FLOOR)

FEET
0 10 20 30 40 50
2 4 6 8

NOTE:-
THIS DRAWING REPRESENTS THE GENERAL LAYOUT OF THE BUILDINGS. ROOMS / FLOOR SPACE WHEN ACCURATE ANALYSIS OF AVAILABLE SPACE IS REQUIRED MEASUREMENTS SHOULD BE CHECKED

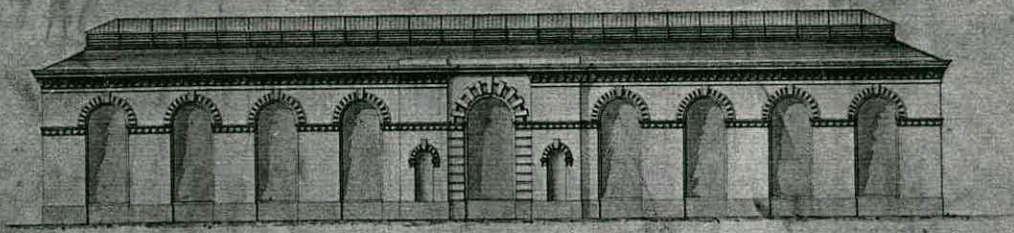
UPDATED TO CURRENT LAYOUT		2	22-3-88
CHANGE	MOD. NO.	ISS.	DATE
CERTIFIED		1	
DRAWING NUMBER	A1-980-61474		

D.O. APP	
TRACED	J. BAKER
ORIG. SCALE	1/16 IN. = 1 FT.


ROYAL ARSENAL WOOLWICH
ROYAL GUN FACTORY DEPARTMENT.
ELEVATION of GUN F9

ROYAL ARSENAL WOOLWICH

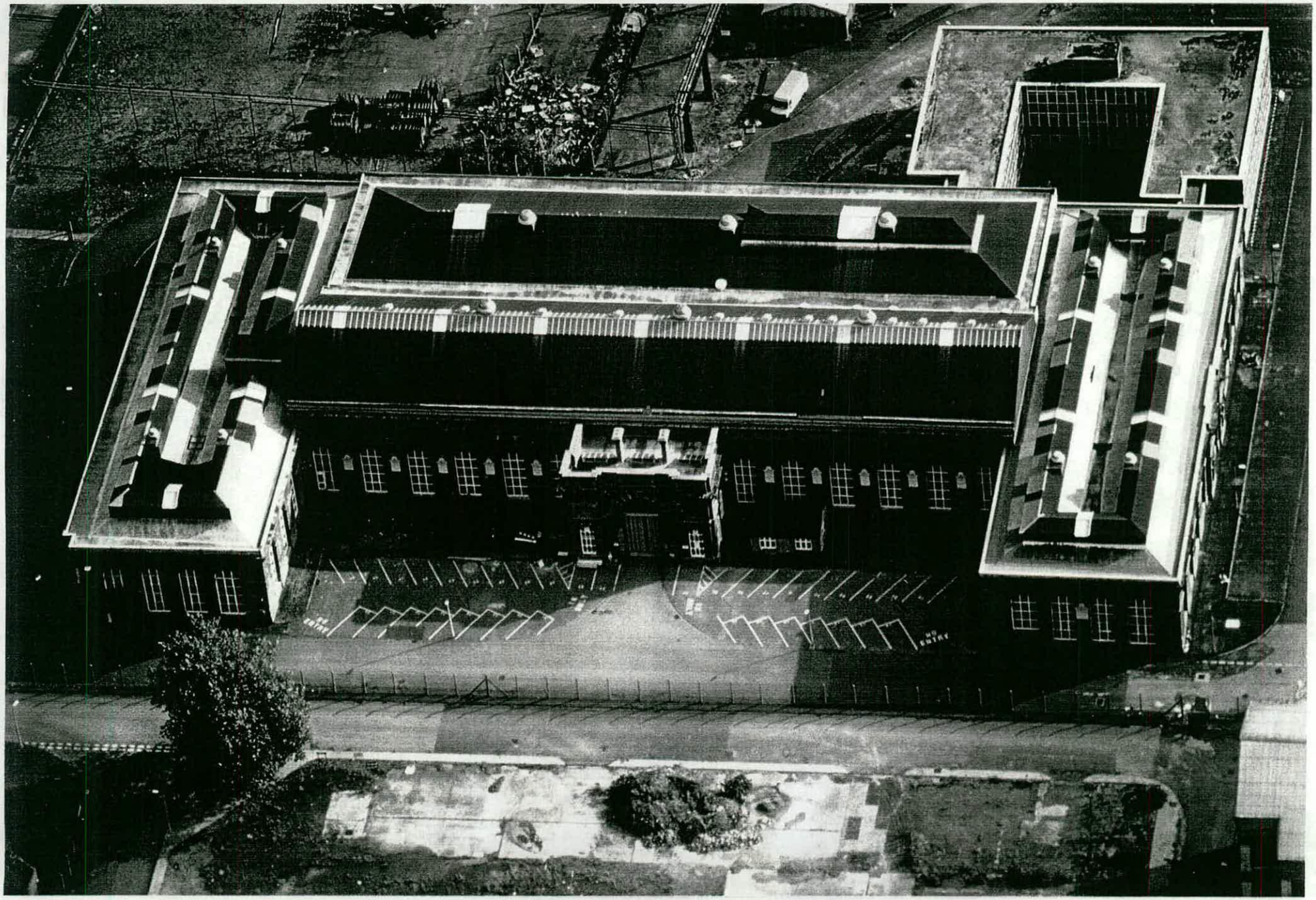
ROYAL GUN FACTORY DEPARTMENT.



WEST ELEVATION of GUN FOUNDRY

SCALE of FEET


25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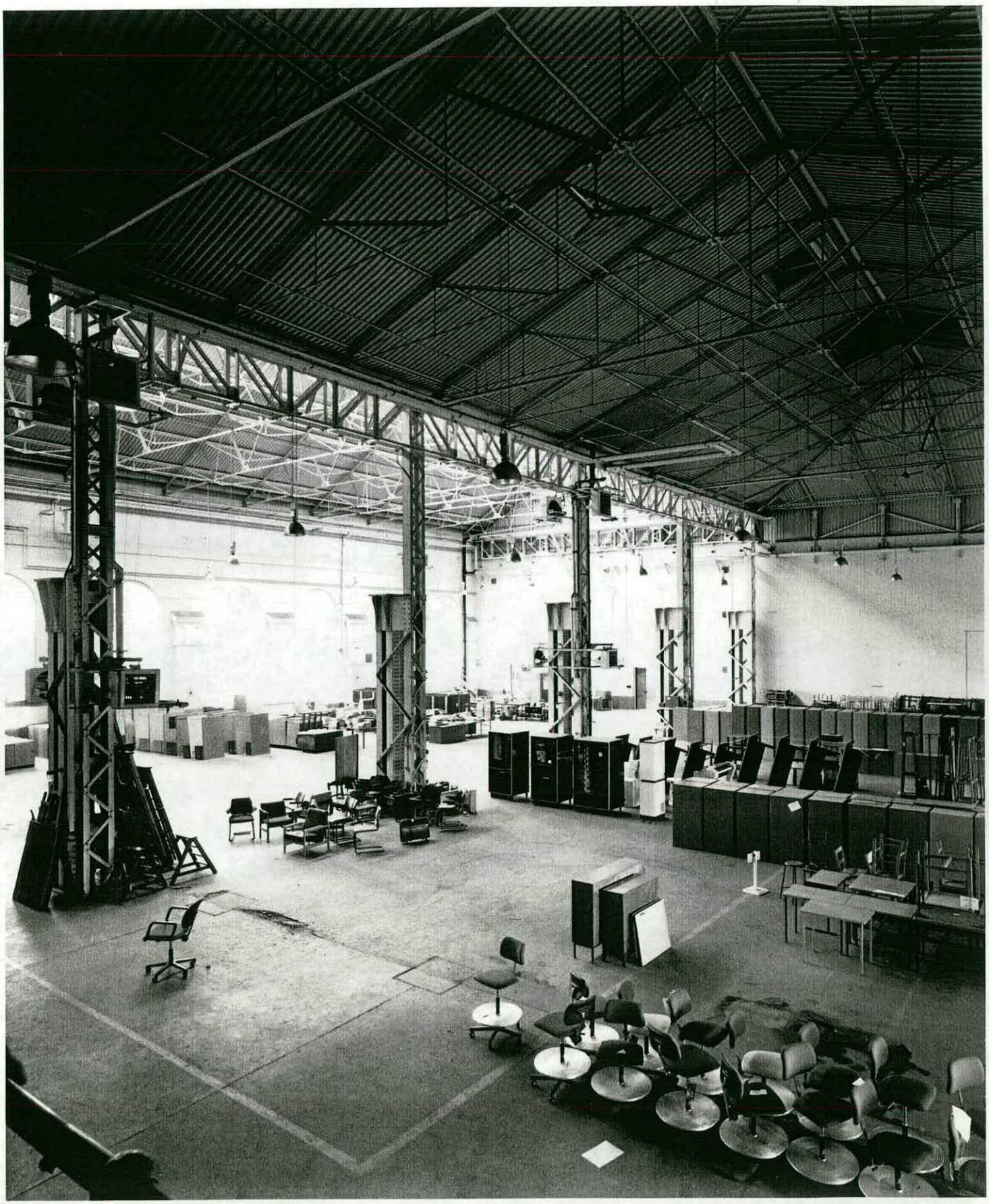
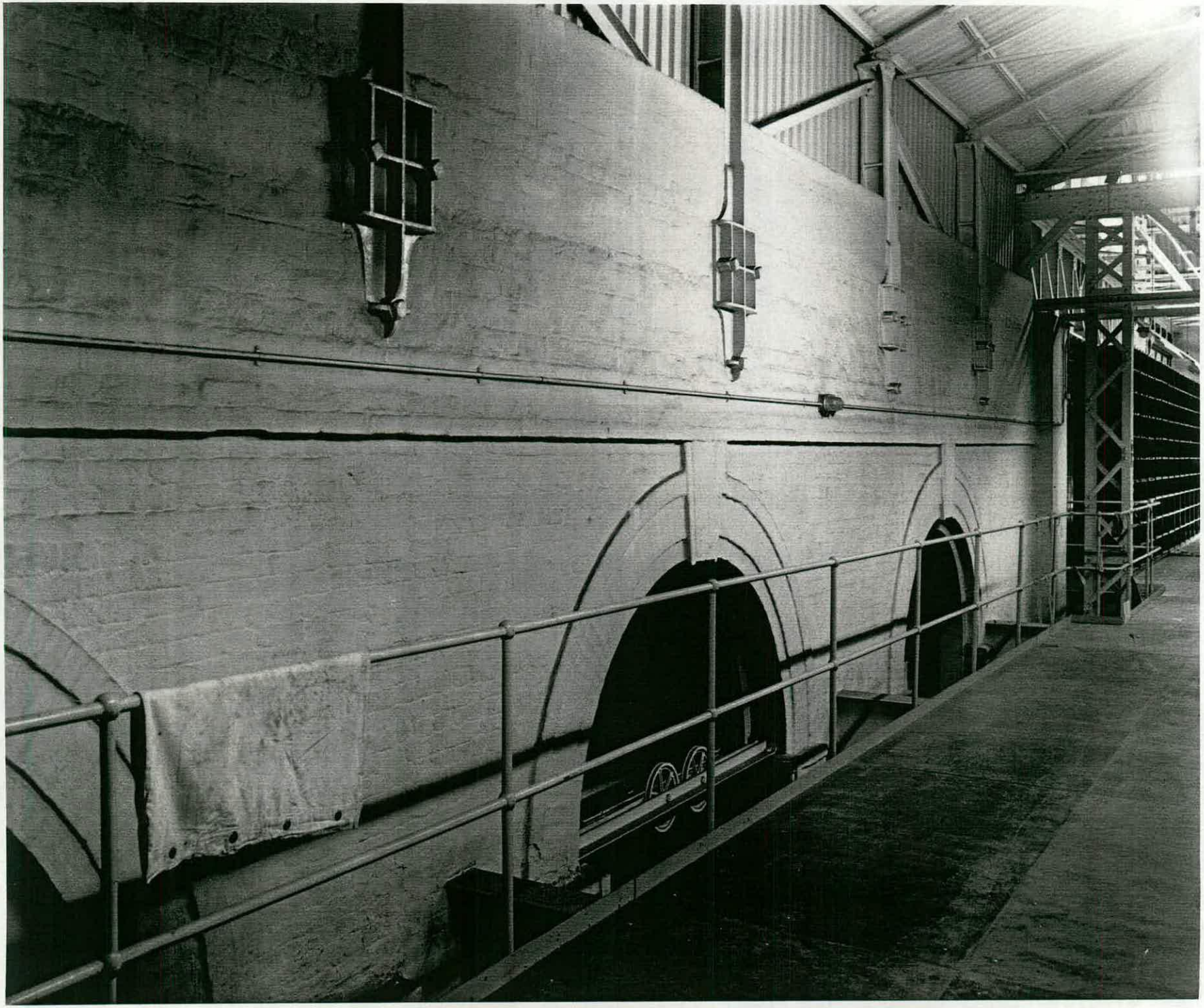
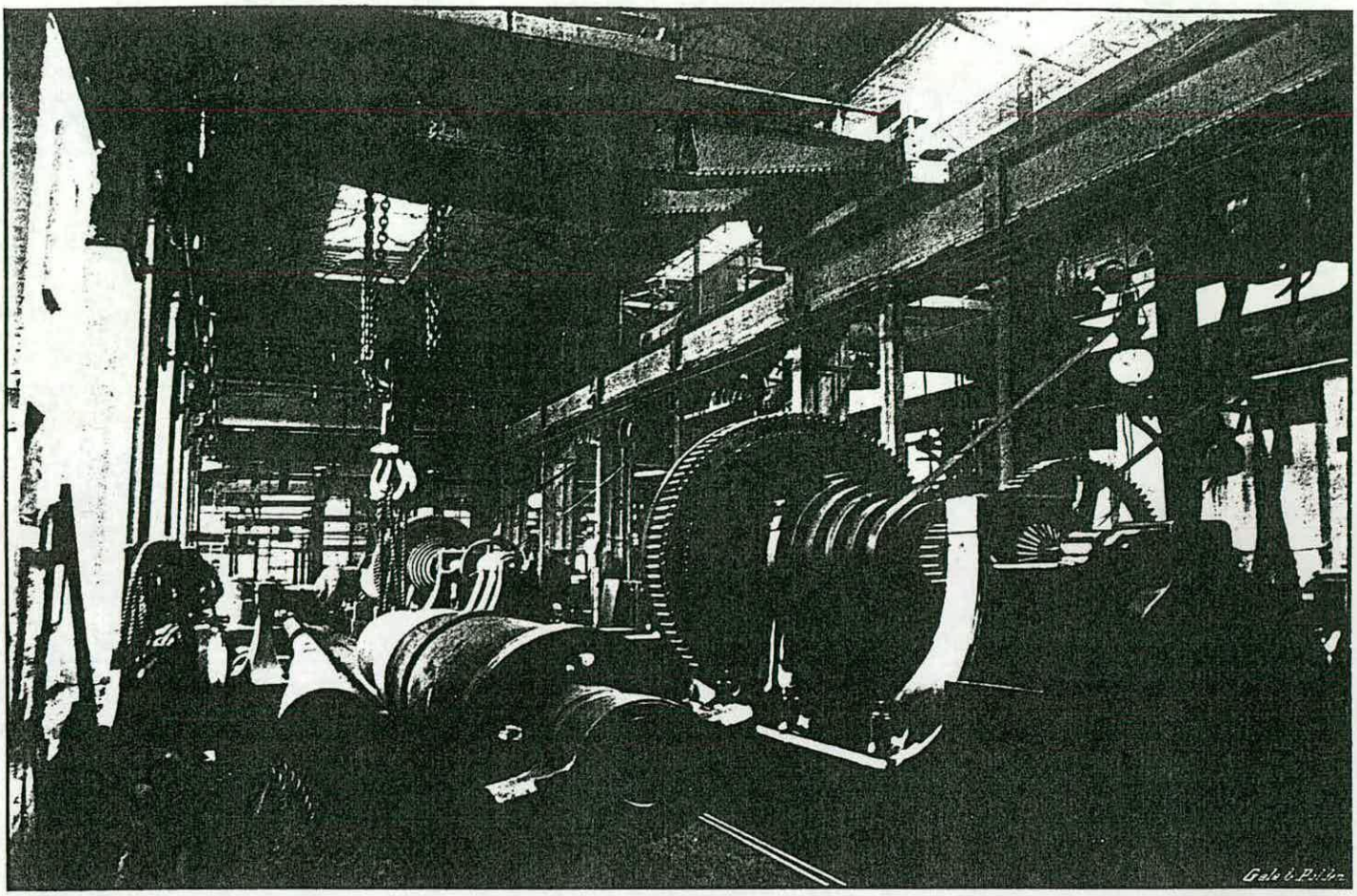
NO ENTRY

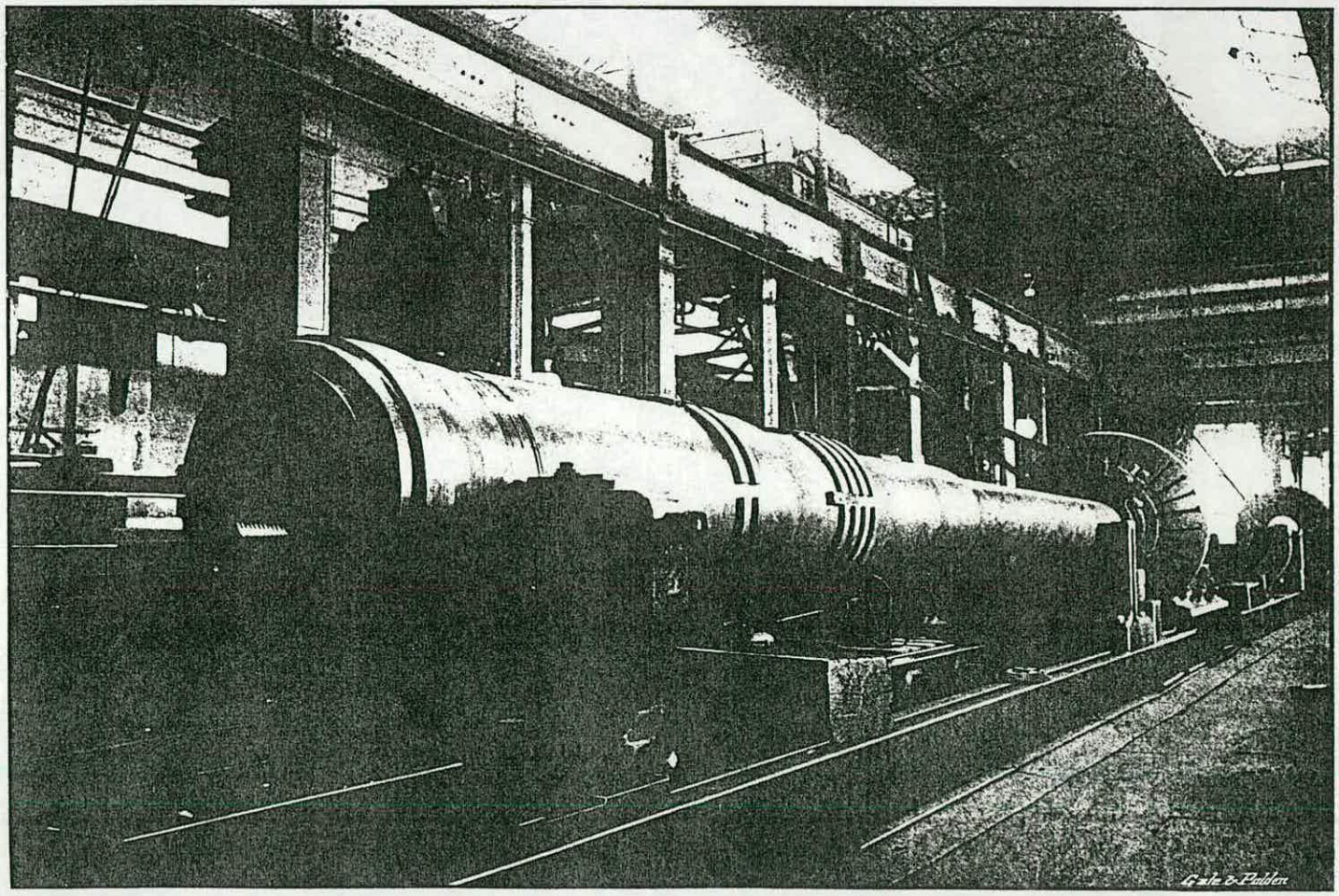



Fire alarm





HEAVY TURNERY DEPARTMENT ROYAL GUN FACTORY, SHEWING A 12-in. OR 50-TON GUN BEING HOISTED IN A LATHE, PREPARATORY TO BEING TURNED.



HEAVY TURNERY DEPARTMENT, SHEWING A 50-TON GUN IN ONE OF THE LATHES.